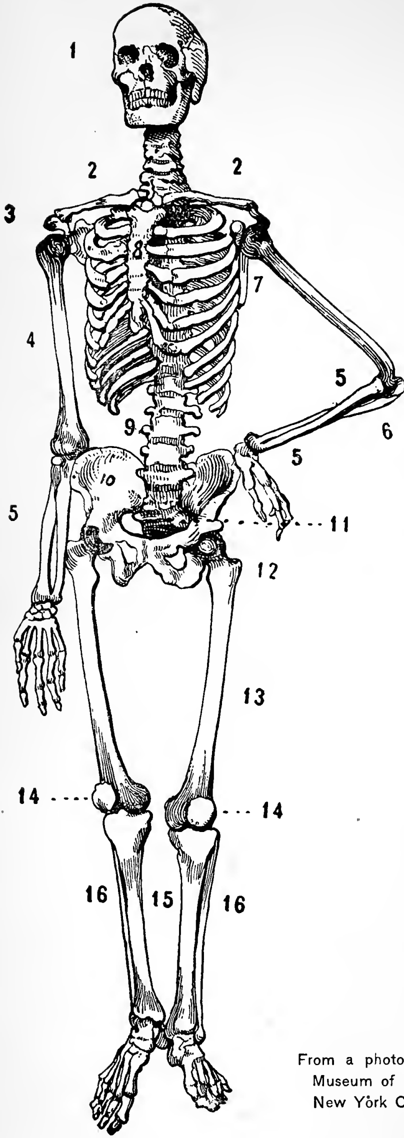
HYGIENIC PHYSIOLOGY

LINCOLN



ADULT HUMAN SKELETON.

1, skull (cranium).
2, collar-bone (clav'icle).
3, shoulder-joint. composed of one end of the clavicle, a portion of the shoulder-blade, and the head of the hu'merus.
4, humerus.
5, radius; in the left arm it crosses the ulna.
6, ulna, at elbow-joint.
7, edge of left shoulder-blade (scap'ula).
8, breast-bone (sternum).
9, lumbar portion of spinal column.
10, is on that part of the pelvis which is called the il'ium. The left hand rests on the projection felt at the hip.
11, sa'crum, which forms the posterior boundary of the true pelvis.
12, hip-joint.
13, shaft of thigh-bone (femur).
14, knee-pan (patella).
15, shin-bone (tib'ia).
16, fib'ula.

From a photograph of the skeleton in the Anatomical Museum of the College of Physicians and Surgeons, New York City.

HYGIENIC PHYSIOLOGY

A Text-Book

FOR THE USE OF SCHOOLS

BY

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BOSTON, U.S.A.
GINN & COMPANY, PUBLISHERS
1893

Typography by J. S. Cushing & Co., Boston, U.S.A.

Presswork by Ginn & Co., Boston, U.S.A.

PREFACE.

THE work which is here presented was planned with the object of giving our young people something rather more directly practical than is usually found in school physiologies.

The execution of this plan will be found to vary somewhat in different parts of the book, owing to the nature of the different subjects treated. Thus, under "Food and Digestion," the reader will find a minimum of anatomical detail, with a good deal regarding the different kinds of food and the practical rules of diet; while in some other parts anatomical and physiological data predominate.

The structure of our own bodies is undeniably an interesting subject of itself. Nor can it be advantageously omitted from a work like the present, forming as it does the basis for hygienic teaching. The merit of the book will be seen, therefore, to be largely a matter of proportion.

The subject of alcoholic drinks has been treated in a separate chapter, with such special additions at the end of other chapters as their respective subjects require. The views presented are intended to be such as will generally be admitted among medical men to represent the best scientific opinion. By an avoidance of statements which would be found to conflict with subsequent experience in the world, it is hoped that the im-

pression produced upon readers may remain permanent. A farther discussion of the subject is found in an Appendix, containing selections from some of the best recent authorities, occupying a non-partisan position.

Nearly the whole of the work has been carefully examined by the following gentlemen, to whom the author's most sincere thanks are due: Henry P. Walcott, M.D., President of the Massachusetts State Board of Health; Charles F. Folsom, M.D.; James J. Putnam, M.D.; Thomas Dwight, M.D.; E. Wigglesworth, M.D.; C. J. Blake, M.D.; Robert Willard, M.D.; and W. H. Rollins, M.D., several of whom are members of the Faculty of the Harvard Medical School. Thanks are also due to Mr. A. Lovell for careful examination of manuscript and proofs.

CONTENTS.

PHYSIOLOGY.

CHAPTER I.

THE TISSUES AND FLUIDS OF THE BODY.

The skin of our bodies is in some respects like the thin sheet rubber which makes a toy balloon. Both are thin, elastic, supple, and water-proof. But in one important respect they are very unlike. The skin of the body, if examined with a microscope, is found to have a *structure.* It is composed of an immense number of small objects of various shapes, fitted together, entirely unlike anything which would be supposed from the external appearance. Rubber has no such internal structure; it is alike in all parts.

The minute objects composing the skin (and other parts also) are chiefly *cells* and *fibres.* They are too small to be seen with the naked eye. Their appearance under the microscope is shown in many of the figures of the chapters following.

Fibres. — From cotton or woollen thread we can easily pick out the fine "fibres" which form the threads. This gives a fair idea of what the word means. A somewhat better idea can be got by examining the coarse, shaggy sides of rough hides, which show the fibrous structure of skin.

Cells. — The meaning of the word "cell" can be quite well understood by examining the structure of a honeycomb. A large part of our bodies is composed of cells, each of which has its wall and its soft contents. In addition, cells usually have a small body in their interior, called a *nucleus.* There is no

single shape for cells, as there is in a honeycomb; they are globular, cylindrical, flat, or long like threads.

Tissues. — The word "tissue" is often applied to fabrics of silk, cotton, and other material. In the case of the body, it signifies the fabrics or substances that are formed by joining and interweaving the cells and fibres.

Fibrous Tissue is a mass of fibres interlaced like felt. Some fibres are elastic; others are not. Fibrous tissue gives strength and firmness, combined with elasticity where required. It forms a casing for some organs, as the brain and the heart; it forms an envelope for each muscle; it wraps and ties together the joints; all the "cords" or sinews are made of it.

Epithelial Tissue is composed of cells of various forms packed closely together. It forms the outer layer of the skin; it also forms a lining for the mouth, throat, and many other internal parts.

Fatty Tissue contains numerous roundish cells filled with fat; between the cells there are meshes or bundles of fibrous tissue.

Bony Tissue (represented in Figs. 1 and 2, pp. 6, 7) is peculiar in having its substance mostly filled somewhat solidly with mineral matter; it has, however, numerous little cavities, with passages connecting them.

Muscular and nervous tissue is described later.

The structure of plants is in many ways like that of living creatures. They contain cells and fibres in abundance, and of many shapes and sorts. The human body has in reality a kind of life like that of a plant; but it has much more besides.

Membranes. — The general meaning of this word is a thin, skin-like structure; thus, there is a membrane on the inside of an egg-shell. In the body there is a variety of "membranes," composed of cells and fibres; they may be considered as a sort of skin, serving to line the cavities and passages in the interior of the body. The most important one is the *mucous membrane,* which lines the mouth, nose, inner ear, eye, throat, air-passages, stomach, and intestines.

The fibrous envelopes of the brain and heart are also called membranes. The "drum" of the ear is a membrane.

FLUIDS.

The human body, like that of animals in general and most plants, contains a good deal of water. If it were possible to evaporate from a person's body all the water it contains, it would lose three-fourths of its weight.

But water is not found pure in the body; it always contains some animal and mineral substances dissolved in it or mixed with it. In connection with many different substances, and in various proportions, it forms a great variety of fluids, some of which are the blood, the lymph, the bile, gastric juice, saliva, tears, sweat.

One of the best-known fluids is the *blood*. This will be described in another chapter. We will notice here, however, that the blood, though it seems to be everywhere, does not fill the body as water fills a sponge; it is all contained in large and small tubes, called *blood-vessels*.

In the parts outside of these blood-vessels there is everywhere found a clear, colorless fluid, called *lymph*. The body in general is kept moist and soft by the presence of this fluid.

There are certain other fluids, which are different from the blood or the lymph in one respect, — they are poured out upon the surface of the body or into the cavities of the mouth, stomach, etc. Among these are the sweat and the saliva. These fluids proceed from certain small openings, which lead from little bag-shaped cavities, called *glands*.

In the diagram (Fig. 50) of the skin, the sweat-glands are shown. This kind is one of the simplest, consisting of a single long tube, straight in one part and curled in another. Some kinds of glands have branches; these may be so numerous, with rounded ends, as to resemble bunches of currants or grapes.

Glands of every sort are surrounded by coils of small blood-vessels. From the blood in these tubes some water

passes through into the cavity of the gland, and with the water go certain other things, as common salt (which can be tasted in tears and perspiration). A gland has the power of choosing for itself which of the many chemical substances in the blood shall come to it, and thus each sort of gland manufactures its own special sort of fluid.

In speaking of the surface of the body, we usually mean the skin. But the body has interior surfaces also. The surface of the mouth is covered with mucous membrane, which is kept moist by the *saliva*, and by *mucus*, produced from glands situated in different parts near the mouth. One of them, the parot'id gland, is in front of the ear and is the part which swells in mumps.

The interior of the stomach has its surface, as the inside of the mouth has, upon which, when food is present, the gastric glands pour out the gastric juice to aid in digestion. The pancreas is a large gland, and the liver is one much larger still, both of which discharge their fluids (pancreatic juice, bile) into the intestine a little beyond the stomach, to continue the work of digestion.

The kidneys are important glands which pour forth certain harmful substances, freeing the body from their presence. In this respect, the skin is like the kidneys, for the perspiration contains some materials which would be injurious if kept in the system.

Secretion is the name given to the formation of these various fluids by glands.

Excretion is secretion for the purpose of getting rid of a substance for which the body has no further use.

SYNOPSIS.

The skin and other parts of the body are composed of vast numbers of minute objects, chiefly cells and fibres. Substances like the gum called *rubber* have none of this structure.

Fibres are like threads; cells are small sacs of different shapes, filled with various contents and containing nuclei.

Fibres and cells are built or woven into tissues. Fibrous tissue is firm. Epithelial tissue consists of layers of cells, often forming a skin or lining. Other forms are fatty, bony, muscular, and nervous tissue. Plants have many similar tissues.

Membranes are skin-like structures of cells and fibres. The mucous membrane is the chief one.

Fluids. — Three-fourths of the human body is water. Mixed with various substances, this forms many kinds of fluid, — blood, lymph, and the secreted fluids.

Secretions are fluids poured out from sac-shaped cavities called glands. Among the chief are the sweat, saliva, gastric juice, pancreatic juice, bile, urine.

NOTE TO TEACHERS.

The very brief statement of general facts here given is placed, for certain reasons, at the beginning of the book. It may, however, be thought judicious to omit it until perhaps two or three of the following chapters have been studied. A beginning can very properly be made at the subject of Bones.

In studying the subject of microscopic structure, some pains ought to be taken that the scholars understand what is really meant.

The cells of many plant-structures furnish a very convenient means of giving the pupil a more real and vivid notion of what the word "cell" means than description can give. A common pocket lens will show with perfect clearness the large cells of the pith of annual plants or the stalks of celery or those of the young, soft leaves or shoots of water-plants. A slice cut thin with a sharp knife should be laid between two bits of glass for examination. For showing cells of the animal body a compound microscope is required.

SUGGESTED QUESTIONS.

Substances with, and those without, structure. Elements or components of structure. Fibres, cells; shape, contents, tissues. Fibrous, epithelial, bony, fatty, tissues. Plant-structure, membrane; examples.

Water in body. Fluids of body. Blood, lymph, sweat, tears, glands; form, action; examples, and uses. Secretion, excretion.

CHAPTER II.

THE BONES AND JOINTS.

BONES.

Structure and Appearance of Bone. — A piece of fresh bone that has not been cooked is usually white on the surface, but if held up to the light it shows a red color internally.[1] If cut

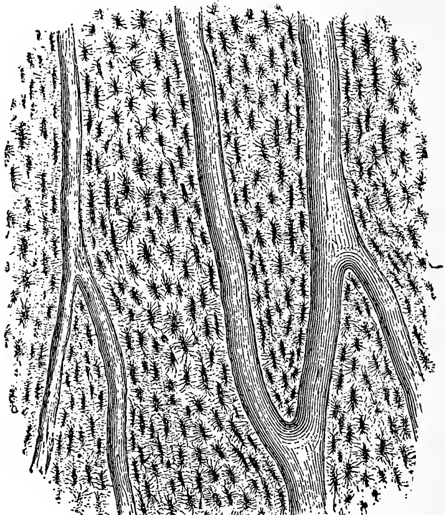


Fig. 1. — Bone structure. A portion taken from the shaft of a thigh bone, cut lengthwise, magnified 200 diameters. In it are seen several canals, or passages for blood-vessels. The small, black objects resembling insects are cavities containing cells, which communicate with each other, and with the canals, by means of many minute, thread-like passages. The nourishing fluids circulate through these passages and cells.

[1] Owing to the blood it contains.

across, it appears red. When prepared for a skeleton, it is nearly white.

The surface is mostly smooth and hard, like ivory; the parts beneath are spongy or porous, with many fine cavities and little thread-like passages for the blood-vessels. Many bones

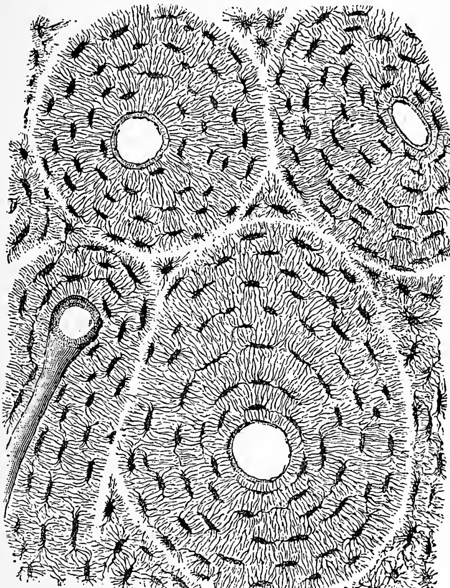


FIG. 2. — The same, cut crosswise. Four canals are seen cut across; one of them communicates with a canal cut lengthwise. The minute passages and cavities are more distinct than in Fig. 1.

have a hollow in the interior; this, in the long bones, is filled with a yellow, lardy substance, called *marrow*. A substance called the red marrow is found in the minute pores and cells.

Composition of Bone. — The bones are not lifeless parts, like the hair and nails. They are as truly alive as any other part of the body. Their life is maintained by the blood which cir-

culates through them in millions of very small tubes, bringing nourishment, as it brings it to the rest of the body.

The life of a bone depends very much on a certain outer coat, called the *perios'teum,* which clings closely to its surface;

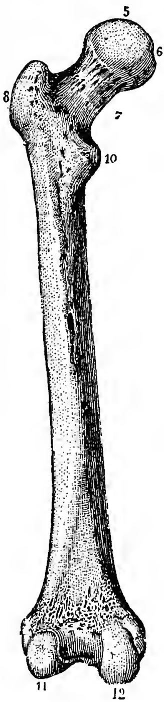


FIG. 3.—The left thigh bone, seen from behind. 5, head; 6, place for attachment of round ligament; 7, neck; 8, greater trochanter; 10, lesser trochanter; 11 and 12, smooth surfaces forming part of knee-joint.

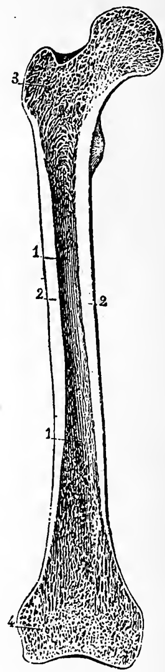


FIG. 4.—The same, cut lengthwise. 1–1, hollow containing marrow; 2–2, showing the thickness of bone at the part called the shaft; 3, 4, spongy structure.

if this coat or membrane is torn off by accident at any part, the portion of bone from which it is stripped begins to perish.

During life, therefore, bone is covered with periosteum, and contains in its pores blood-vessels, blood, and the fatty mate-

rial, called marrow. When all these are removed, we have remaining the substance, properly called *bone*. Yet even this is not a simple substance, but consists of two entirely different ones, intermingled with each other, one of which is of an animal nature and easily decays (gelatin), while the other is mineral (phosphate of lime, carbonate of lime, and other ingredients). The animal and the mineral parts are so mixed as to seem like one substance.

It is easy to dissolve out the mineral components. For this purpose, immerse a bone, with the surface cleanly scraped, in muriatic acid diluted with water. In a few days the bone will lose its brittleness, and can then be bent, or, if its shape permits, can even be tied in a knot.[1]

The animal part can be extracted from a bone by boiling under a high steam-pressure; or can be burned out by fire. In the latter case what is left is called bone-ashes.

The form of the bone remains the same after each of these experiments.

Fig. 5.—Thigh bone of child. Pieces 2, 3, 4, are attached to shaft (1-1), by cartilage only; fully united in 18th year; 5, in 20th year.

Besides the gelatin which is distributed through the bones, there is a similar substance, called *cartilage* or *gristle*, which covers the ends of bones. It is a tough, elastic material, easily cut, but incapable of breaking. In very young infants, the bones consist chiefly of cartilage. The bony material is deposited in the cartilage, day by day and year by year, and it is not until about the twentieth year of life that the bones be-

[1] Two ounces of the strong "commercial" acid may be mixed with a pint of water. On taking the bone out, wash it before handling.

come fully hardened. Indeed, the process continues through life; and in middle age the front part of the ribs (which till then consist of cartilage) begins to turn to bone. By placing the hands on the sides, over the lower ribs, and pressing firmly inwards, it is easy for a young person to feel the elasticity of the cartilaginous parts.

Properties and Uses. — The bones have three principal uses.

1. As a covering and protection to some parts which are not directly attached to bone. The brain is completely covered by the skull; the heart and lungs are shielded by the chest-bones; the eye lies in a deep, round cavity of the skull.

2. As supporters of the weight of the body. The leg-bones, for instance, often have to sustain one or two hundred pounds, or even more; besides receiving heavy shocks in jumping.

3. As levers for moving the parts of the body. For this purpose, the muscles are attached to them. Almost all the movements of the body are produced in this way.

It is evident that strength is one of the first qualities required of a bone. In securing this, the material has been used economically and skilfully. The bones of the legs, for instance, are made hollow, as architects make iron columns hollow, because that is a stronger form than a solid column of the same weight would be. But at the point where the thigh-bone bends at an angle (*i.e.* the neck of the bone) there is especial danger of breaking; there, consequently, the interior of the bone is curiously strengthened by cross-pieces or braces adapted to prevent this accident (see Fig. 4). All the "long bones" are hollow for similar reasons, and many other bones are soft and spongy in the middle; but all have their greatest hardness at the outside, where it is most needed.

Bones also require to be elastic, for resisting blows or sudden shocks in falling or leaping. This property of elasticity is due to the gelatin which they contain. The bones of children contain less mineral matter than those of adults; children, therefore, seldom break a bone in their frequent falls. The

bones of very old people are in exactly the opposite state, and are very brittle and easily broken.

Form. — The shapes of bones differ exceedingly. Each one has its own proportions and outlines, depending on the use it

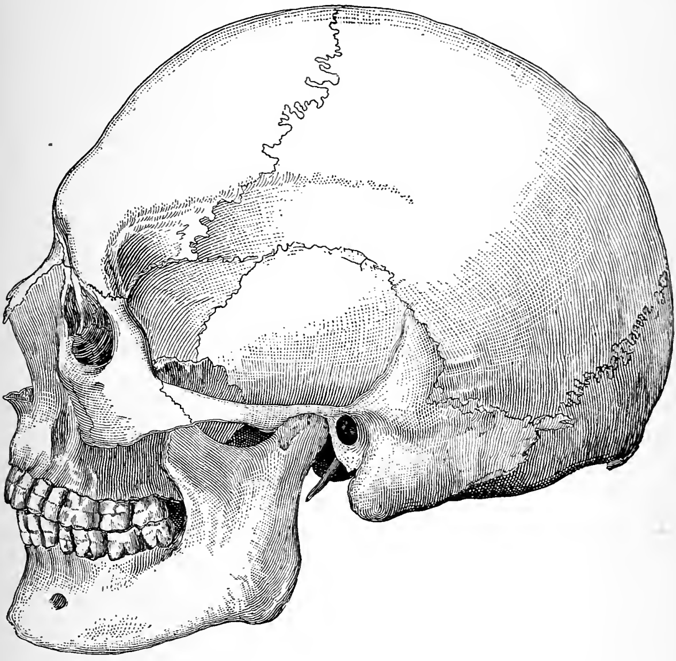
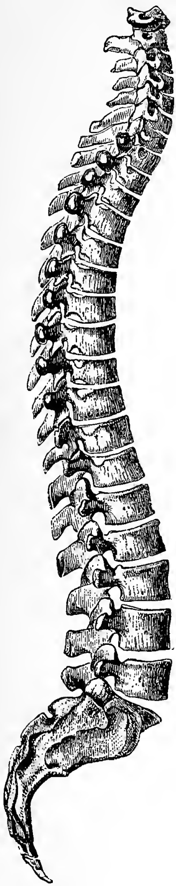


Fig. 6. — Skull of adult, of the white race. The zigzag line running down from the summit is the suture which joins the frontal (forehead) bone to the pari'etal bone behind. Behind, near the base, another suture joins the pari'etal to the occip'ital bone. The tem'poral bone (temple) lies behind and above the opening of the ear. The hinge of the jaw is close to the ear, in front. The temple is seen to be a depressed space: this in life is filled with a strong muscle.

is intended for. We may divide bones into three classes, — the *long*, the *flat*, and the *irregular*. It is evident that the arm and the leg require long bones. That of the thigh is the longest in the body, and is about one-fourth of the person's height.

The hands and feet also require bones which are long in proportion to their thickness. The ribs are the longest of any, proportionally to their size. Of the flat bones, the shoulder-blades and the bones of the surface of the skull are the best known. Those of the face, the base of the skull, the wrist, ankle, and spine are irregular.



THE SKELETON.

The skeleton, or framework, of the body, is composed of bones supplemented (as above mentioned) by cartilages, and bound together by tough white fibres resembling sinew.

A simple way of regarding it is to consider it divided into the bones of the head, of the trunk, and of the limbs.

Head. — The bones of the skull are complicated and irregular. Those forming the vaulted part may be seen to be divided off into sections by zigzag lines, where the bones join by dovetailing their edges. The union is so fine that the whole practically forms one bone. The lines resemble a sort of rough seam; hence they are called *su'tures* (from the Latin *sutu'ra*, a seam). (See Fig. 6.)

The arched form of the skull gives it greater strength, and enables it to bear heavy weights and resist blows. There are

Fig. 7. — Vertebral column, seen from the right side. The bodies are represented separated by spaces, which in life are occupied by cartilaginous cushions. The spinous processes project behind; the transverse processes project towards the observer, at points near the bodies. Openings for the exit of nerves are seen near the transverse processes. The curves of the spine should be noticed.

twenty-eight bones in the skull, of which eight belong to the head part, fourteen to the face, and six very small ones are found in the ears.

Trunk. — The bones of the trunk comprise the *spine*, and thŏse of the two important cavities called the *chest* and the *pelvis.*

The *spine* (also called back-bone, vertebral column, spinal column) is formed of twenty-four irregular bones, called *ver′-tebræ,* resting one on the other so as to form a column. The long line of knobs at the middle of a person's back is not the main body of the spine, but consists of the tips of certain bony projections, extending from the bodies, or more solid central portions, of the vertebræ. The bodies are thick pieces of bone, resting squarely one on another. Between the single pieces there comes a firm, thick packing of elastic material. The joinings of the bodies, therefore, though very firm, are not rigid, but allow a little bending in different directions. (See Fig. 7.)

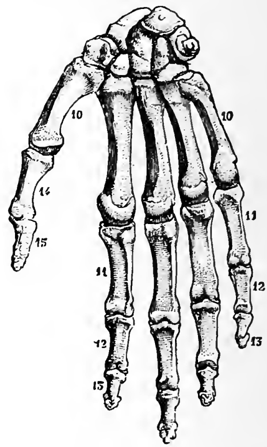


Fig. 8. — Bones of right hand, seen in front. Wrist bones above. 10–10, metacarpus; 11–11, first joints of fingers; 12–12, second joints; 13–13, third joints; 14 and 15, joints of thumb.

A ring of bone projects behind from the body of each vertebra. The twenty-four rings together form a sort of tube (the "spinal canal"), in which the spinal cord lies.

Other projecting pieces extend sideways and backward, and are so jointed together as to give firmness combined with flexibility. None extend from the front, but at the sides there are twelve pairs of *ribs,* jointed to the bodies of twelve vertebræ, which curve forward around the chest. They are joined in front to the *breast-bone,* except the two lowest pairs, which

are called the *floating ribs* and are free at the front end. The ribs, with the back-bone, form a sort of basket, widest below, but open both at top and bottom, called the *thorax*, or chest. The chest contains the heart and lungs.

There are seven vertebræ in the neck, and five in the lower part of the trunk, which have no ribs attached to them. The lower are much larger and stronger than the upper ones.

The five lower vertebræ form a backing to the part of the trunk called the *abdo'men.* They rest on a strong structure called the *pelvis* (Latin for basin). The pelvis is composed of a middle piece, the *sacrum,* which is a continuation of the vertebral column, and two side-pieces (the innom'inate

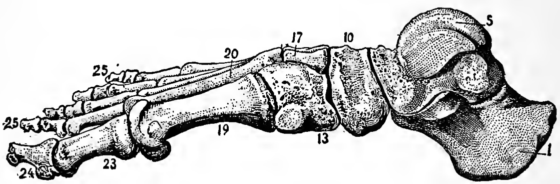


FIG. 9. — Bones of right foot, from inner side. 1, os calcis (heel); 5, joint surface of astragalus; 10, scaphoid; 13, greater cuneiform; 17, lesser cuneiform; 19, 20, first and second metatarsal bones; 23, first phalanx of great toe; 24, second phalanx of great toe; 25, second and third phalanges of the other four toes.

bones), which curve around and meet in front, forming a ring of bone. The pelvis is the lowest part of the trunk-skeleton. It is so shaped as to give some support to the abdomen. The side of the pelvis, where it is felt projecting, is the *hip.* The hip-joint connects the thigh-bone to the pelvis.

Limbs. — The arm resembles the leg in many ways. Each consists of a single upper long bone, two long bones below, eight bones at the wrist, corresponding to seven in the ankle, with nineteen in each hand and foot. The knee-pan does not correspond to any bone in the arm; it makes the number equal in arm and leg.

The four limbs are attached to the trunk by ball-and-socket

joints. They are not connected directly with the spine, but with certain side-structures, which, in the case of the arms, consist of the two *collar-bones* and the two *shoulder-blades.*

The collar-bone is slender and curved, and is easily traced at the lower boundary of the neck. Its inner end joins the breast-bone, its outer end meets the shoulder-blade. Taken together these form the *shoulder-girdle.* The shoulder-joint is at their point of junction. The shoulder-blade is not jointed to any bone behind; by moving forward, it allows the arms to be thrust forward or raised.

The pelvis has already been described as a part of the trunk, but a more scientific statement would be that, while the sacrum belongs to the spine, the two large, irregular bones which join the sides of the sacrum are analogous to those of the shoulder-girdle. They form the *pelvic girdle,* to which the leg is jointed.

JOINTS.

Some bones are joined in a fixed, immovable way, while others can be moved more or less at the point of juncture.

The *sutures* of the skull afford an example of immovable joining. In infancy, the flat bones forming the roof and sides of the skull are soft and flexible, being composed of cartilage, except a small patch of bone in the middle of each; they do not even meet each other at the edges. As growth proceeds, the bones first touch, then interlock by a great number of fine dovetailings; the central patches of bone also spread until the whole is hard and solidly joined together. In advanced life the sutures may become obliterated by the continued development of bone.

Another example is furnished by the three distinct bones which form the pelvis — the *sacrum,* and the right and left *innom'inate* bones — united closely and immovably, though not with sutures.

These immovable joinings of the skull and pelvis are not *joints* in the strict sense. A true joint is a connection between

bones which allows them to glide over each other at the points where they touch.

The sacrum, on which the spinal column rests, forms a sort of continuation of the latter, and originally consists of several distinct vertebræ, which at a later time become one structure. The *coccyx*, which occupies the place of a tail in the skeleton, is placed at the lower end of the sacrum, and in adult or advanced life is often united with it. Each innominate bone consists, in infancy, of three bones, which in adult life are united so closely as to appear one.

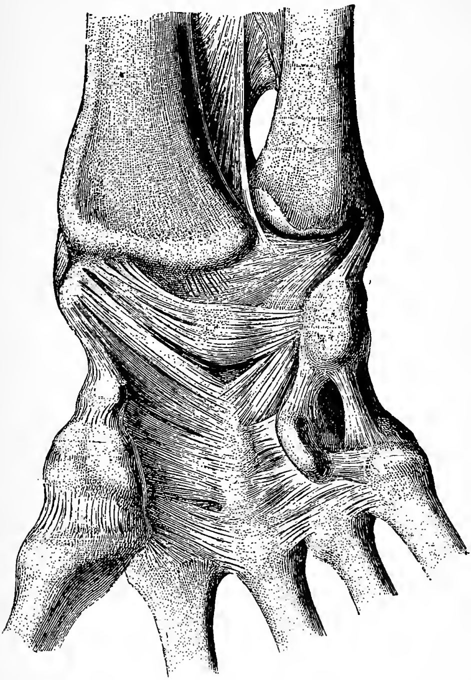


FIG. 10. — Ligaments of right wrist, front view.

The structure of a joint presents the following features:

1. A thin layer of cartilage covering each end of the bones that are to be joined. This gives a perfect fit and a smooth-gliding surface.

2. A lubricating fluid, in quantity only sufficient to keep the surfaces of cartilage perfectly slippery, so as to make motion easy and prevent the ends of the bones from wearing against each other. This is called *synovial fluid.* It resembles the white of an egg in appearance.

3. The edges of the bones are fitted with a ring of strong material called the *capsule,* which holds the bones together, and prevents the fluid from escaping.

4. Additional strength is given by other bands of fibrous tissue called *ligaments.*

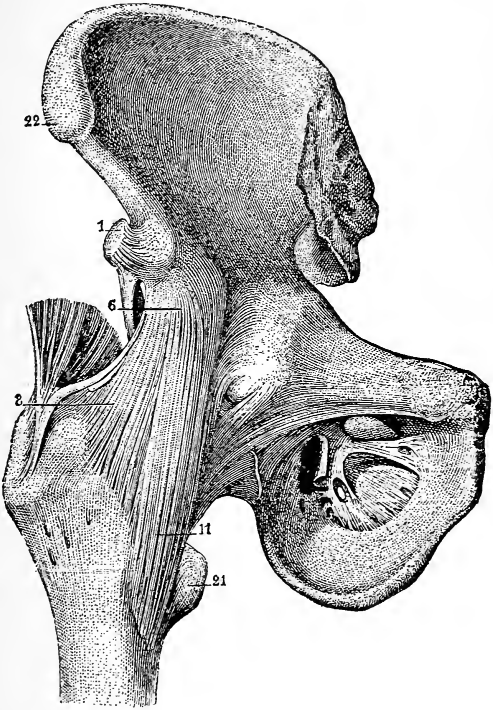


FIG. 11.—Ligaments of right hip, seen in front. 1, cut tendon of great muscle of front of thigh, turned up; 3, 6, 11, great fan-shaped expansion of ligament; 21, lesser trochanter; 22, projection of the hip bone, which can be felt a short distance above the joint.

The capsule and ligament are composed of a white material, which is the same that is seen in the white, stringy, tough parts of meat, or in the sinews. It is exceedingly strong,

but not elastic. It is used in many places to fasten bones together; sometimes immovably, at other times loosely, in the manner of a joint. It is a necessary part of joints, and is em-

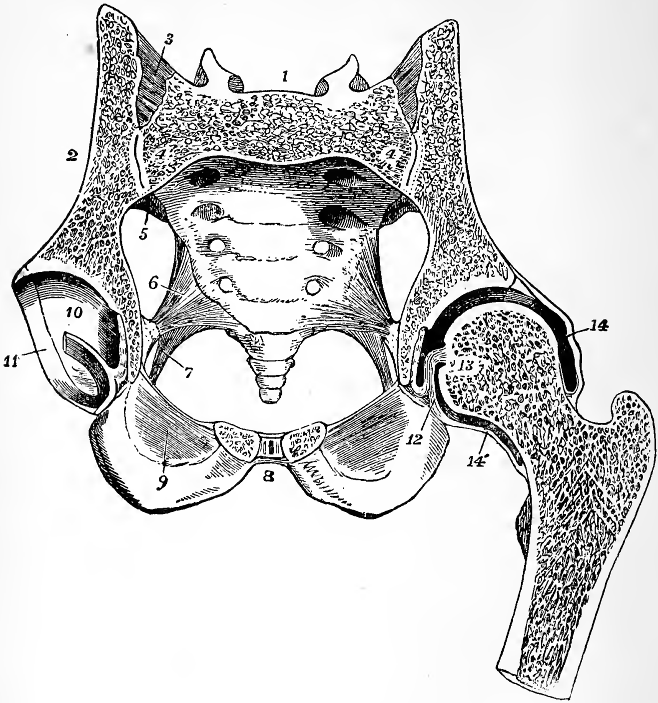


FIG. 12.—Section through pelvis and hip-joint, seen in front. 1, sacrum; 2, ilium; 5, 6, 7, 8, 9, ligaments; 10, cup-shaped cavity for head of thigh-bone; 11, rim of cartilage; 12, round ligament; 14–14, cavity of the joint, with capsule enclosing it.

ployed in making the synovial sacs. The name of this substance is *white fibrous tissue.* It has many other uses besides those described here. Every muscle is covered with a thin, transparent sheet of it, and is fastened to the bone by a thicker portion, often resembling a cord.

In "limber-jointed" persons the ligaments joining the bones are looser, and do not set the bones so firmly together as is the

case in other persons. The joints are most flexible in youth. By beginning in childhood, some persons are trained to bend their limbs and back in extraordinary ways, and become the contortionists or india-rubber men of circuses.

There are four kinds of joints, — the *ball-and-socket*, the *hinge*, the *pivot*, and the *gliding*.

The ball-and-socket joint is that which permits the greatest freedom of movement; it is employed to connect the limbs to the body.

The hip-joint displays this structure better than any other. There is, in the hip-bone, a cup-shaped cavity, into which the rounded head of the thigh-bone fits, turning freely, and allowing the bone to move in all directions. Both the cup and the head of the bone are covered with smooth cartilage, making them fit each other closely. The synovial fluid is kept in its place by a sac or capsule, which encloses the whole joint, and is very flexible, but very strong and tough. Its shape is somewhat like that of a cuff or wrister, the upper edge of which is attached around the edge of the cup, and the lower edge around the bone. This arrangement makes an air-tight joint. The hip-bone is kept in place chiefly by the force of atmospheric pressure, or what is commonly called suction.

There are other means, however, for keeping it in place; such are, the capsule itself, which is quite strong; also, a certain ligament or cord inside of the capsule (the "round ligament"), which ties the head of the bone to the bottom of the cup, and prevents the bone from turning around too far while revolving. The joint is further wrapped in ligaments outside of the capsule, as seen in Fig. 11. The great muscles of the parts, also, are constantly drawing the thigh and hip together.

The arm is joined to the shoulder-blade by an arrangement somewhat like the hip-joint, but the cup is very shallow. A part of the shoulder-blade curves around over the head of the arm-bone, forming the point of the shoulder; it serves to protect the joint, and helps to keep the arm in its socket. The

movements of the arm are much freer than those of the hip, which is, of course, a convenience; but at the same time the arm is much more frequently forced out of its socket, or "dislocated," than the hip.

Hinge-joints are such as move in one definite direction, and back again, like a pocket-ruler, — mathematically speaking, in one plane. Among the chief are those of the knee, the elbow, the fingers, and the toes. The jaws move by hinge-joints, which have, however, less fixity, and permit motion sideways, such as is required in chewing. The joints between the fingers and hand are hinged, but by laying the hand flat on a table

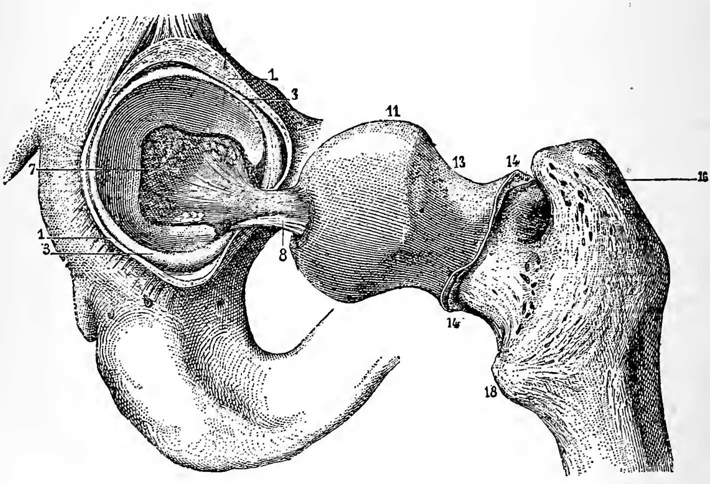


FIG. 13.— Hip-joint, opened by cutting the capsule circularly. 1, capsule; 3, ring of cartilage; 7, 8, round ligament; 11, head of bone; 13, neck; 14, capsule, cut edge; 16, greater trochanter; 18, lesser trochanter.

there is seen to be considerable side-play. The wrists and ankle are a sort of irregular hinge-joints.

Certain processes or projections of bone may be seen in the skeleton at the elbow, in front and behind, which prevent motion beyond a certain point. Ordinary door-hinges have a similar contrivance.

A pivot-joint is seen in the connection of the radius with the humerus at the elbow. This pivot action can be seen and felt in a thin arm, by resting the elbow on a table, and letting the hand turn as in using a gimlet. By placing the fingers against the person's elbow, as it rests on the table, it will be seen that the hinge part may remain unmoved while the pivot is revolving.

Another pivot is used to enable the skull to rotate upon the top of the spinal column. Its construction can be seen better than described.

The gliding - joint is found between the small bones of the wrist and ankle, where there is but little motion.

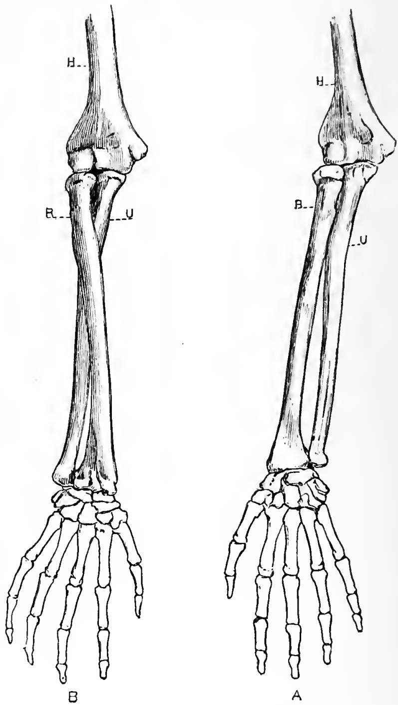


FIG. 14. — Right arm. *A*, with palm shown; *B*, with back of hand shown; *H*, humerus; *R*, radius; *U*, ulna.

The spinal column is capable of considerable bending in all directions. The twenty-four pieces of which it is composed are not jointed together in any of the above ways; they are connected by a series of cushions, which also serve the purpose of ligaments. The joining of two vertebræ might be imitated by cementing two blocks of wood together with a sheet of hard rubber, which would hold the blocks firmly together, and admit of a little motion. By means of twenty-two such joinings the spine as a whole is enabled to bend a

good deal. There are, however, true joints between the first and second vertebræ, also between the skull and the spinal column.

Remarks on the Skeleton. — The skeleton, taken together, is an absolutely necessary part of our organism. If a person could be deprived of his bones and cartilages, he would become a mass of soft material, incapable of moving, and even of breathing, and would perish in a few minutes.

There have been persons whose joints have been so stiffened by disease, that they practically do not exist. Such persons can still eat, digest, breathe, and speak, but they have little more power of motion than if they were statues. All our movements (except those of the internal soft organs) are due to the action of muscles upon joints.

Some animals, however, are so constructed as to be capable of life without possessing any hard parts corresponding to a skeleton. Such are slugs (snails without shells) and jelly-fish.

Many animals have their skeletons outside in the form of a shell or crust, like lobsters.

There is a very large class of animals, of widely different forms and habits, which possess skeletons that are essentially like that of man. They all have a back-bone, with a skull, ribs, and (in many cases) upper and lower limbs. The name of this class is the *Vertebrates.* It comprises, first, those which, like the human race, have the power of giving suck to their young — the *mammalia;* then the *birds,* the *reptiles,* and (lowest of all) the *fishes.*

HYGIENE OF THE BONES AND JOINTS.

The word "hygiene" means the science of health. It teaches how to make and keep ourselves well and strong, and to avoid disease.

The care of the bones should begin in infancy. An infant's bones are at first soft and weak. In order that they may grow firm and solid, its food must contain lime and phosphorus (see

page 9). Milk contains these substances in a fit proportion, and is therefore suitable for young children.

A well-fed child may be compared to wheat growing in a good soil, and sucking up from it the lime, phosphorus, and many other things which it requires.

Rickets is a disease in which the bones do not become firm as soon as they ought; the children's leg-bones, for instance, may become bent (bow-legs, knock-knees), or the chest may grow out of shape (pigeon-breast). Scrofula often affects the joints. Both diseases are largely caused by poor food, and want of fresh air and sunlight, in childhood. They may be inherited from unhealthy parents.

Rheumatism is often due to cold and dampness. It can, therefore, to some extent be prevented.

Little children in school often have to sit on seats that are too high for them, so that their feet do not reach the floor. All persons need a firm support for the feet while sitting; the want of it is not only most uncomfortable, but may cause deformity of the leg in the young.

Twisted spine (spinal curvature) is very common among young persons who do not take enough exercise; it is explained further under "Muscles."

Fracture means a breaking. A bone can be broken by a blow or fall, as a stick of wood can. The same power that made it and caused it to grow supplies the means by which the broken ends of a bone can grow together, if they are kept in place. The surgeon's duty after "setting" the bone (putting it in place) consists simply in arranging the bandages so that the healing shall go on quietly, undisturbed by movements. Whoever happens to have charge of a person with a broken limb before a surgeon arrives should be most careful to prevent unnecessary movements of the broken parts.

A sprain is a wrench received by a joint, in which some of the fibres of the joint are more or less torn. It is excessively painful, and often requires as long time for recovery as a broken limb.

EFFECTS OF ALCOHOLIC DRINKS.

If the parents are drunken, the child will often be born weakly, with a tendency to scrofula or rickets.

Spirituous drinks of all sorts, unless used as medicines, should be forbidden to children, as being most injurious, and liable to make them permanently feeble.

The bones do not, on the whole, show the bad effects of these drinks very much.

Gout, however, is a disease of adults, which is due to excess in "good living" (that is, "high living"), meaning a superabundance of animal food, with a free use of alcoholic drinks. It is very painful, lasts many years, and causes deformity of the joints.

SYNOPSIS.

Description. — The color of prepared bone is white; of unprepared, red inside and white outside. The surface is smooth, interior spongy or porous. Many bones are hollow. Their cavities are filled with marrow. They are nourished by great numbers of blood-vessels. The outer coat (periosteum) is essential to the life of a bone.

Composition. — Bone is composed of an animal substance (gelatin) intimately combined with mineral substances (phosphates and carbonates of lime, etc.). When the latter are removed by acid, the bone becomes flexible; when the gelatin is removed by boiling or burning, it becomes brittle, without losing its form.

Cartilage, a tough, elastic material, covers the ends of bones; in infants it forms the chief component of the whole bone, and complete hardening by deposit of mineral salts does not occur till about the age of twenty years; in later life the hardening becomes excessive. The ribs of young persons are very elastic.

Uses of Bones. — They hold the soft parts in place and give shape to the body. They protect internal parts. They support the weight. They form levers to move the body. Bones are made strong and hard on the outside, while inside, where strength is not required, they are spongy or hollow. They are elastic, from the presence of animal matter; most so in children, while in old persons they become very brittle.

Forms. — Very various. May be divided into long, flat, and irregular. The longest is the thigh-bone. The limbs and thorax contain many long bones. The shoulder-blade and some of the skull-bones are flat.

The Skeleton or framework of the body is composed of bones and cartilages bound together by tough white fibres. It may be divided into three regions, — head, trunk, and limbs.

The Head. — The bones of the head are very irregular. Those of the skull are dovetailed, looking as if joined by seams (sutures); their arched shape imparts strength. There are eight bones in the skull, fourteen in the face, and six very small ones in the ears.

The Trunk includes the spine, with thorax and pelvis. The spine comprises twenty-four vertebræ arranged like a column. Their projecting spinous processes can be felt as a line of knobs in the back. The main part of a vertebra (its body) is a thick, flat, round bone, separated from the corresponding parts of the next vertebræ by a firm, thick, elastic packing. A ring of bone projects backward from each body; the twenty-four rings form the spinal canal. The thorax includes the ribs and breast-bone. The pelvis is composed of the sacrum and two haunch-bones (the ossa innominata).

The Limbs. — The number of bones is equal in an arm and a leg. The arms are joined to the trunk by the shoulder-girdle (collar-bones and shoulder-blades); the legs, by the pelvic girdle (or pelvis).

The Joints. — Bones are united either fixedly or by joints. The sutures are immovable joinings. The sacrum, and ossa innominata, are each composed of several, which are united by growth. A joint contains cartilage, synovial fluid, a capsule, and ligaments. Capsules are composed of white fibrous tissue, tough like sinews.

There are four classes of joints. The hip and shoulder exhibit the ball-and-socket principle well. The hinge is shown in many joints of the limbs. The pivot-joint acts at the elbow, associated with a hinge-joint. Gliding-joints occur at the wrist and ankle. The vertebræ are united by cushions rather than joints.

The skeleton is essential to our life. Most of our motions are made by its aid, combined with muscles. Some animals have no bones; some have an external skeleton; the highest animals (vertebrates) possess a skeleton which is much like that of man, especially in the fact that it contains a back-bone.

Hygiene. — The bones of infants and children require to be built

up with phosphorus and lime, which must be present in the food. Rickets is a disease in which the bones are soft through defective nutrition. Scrofula often attacks joints. Improperly shaped seats may cause deformities. Fractures are repaired by the processes of nature, if kept at rest. Sprains are often as serious as fractures.

Alcoholic Drinks. — See the text.

SUGGESTIONS FOR QUESTIONING THE PUPIL.

It has been thought best to avoid the formality and constraint of printed questions. In what follows, the teacher will find that the statements of the text are referred to, or pointed out, by the use of single words or short phrases adapted to form the *basis* of the examination. It will not be difficult to build upon these a variety of questions which will test the pupil's knowledge more thoroughly than would be the case in using fixed formulæ. For instance: if speaking of periosteum, the teacher may ask, "What is the outer coating of bone called? and what is its use?" or, "What is periosteum?" or, "What structure (or membrane) is essential to the life of a bone?" etc.

The synopsis of the chapter is adapted to call to mind the leading points in case of a rapid review. It may also be found useful (at the teacher's option), during the first study of the subject.

Bone. — Color. Surface. Interior. Structure. Contents. Periosteum. Composition. Acids, effect of. Boiling. Cartilage. Infants' bones. Uses of bones. Strength. Elasticity. Forms; name examples.

Skeleton; divisions. Bones of skull — character, number, arrangement, junctions; form of skull. Spine — number of vertebræ, and their three divisions. Vertebræ — body, ring, projections, junctions. Bones forming the thorax. Abdomen. Pelvis. Sacrum. Hip. Limbs — bones, joints, connections with trunk. Shoulder-girdle. Pelvic girdle.

Joints. — Two sorts of joinings. Sutures — their development. Pelvis — components and junctions. Definition of true joints. Four features of the structure of a joint. Capsule. Ligaments. Flexibility. Four kinds of joints. Hip-joint — cup, capsule, ligaments; how strengthened. Shoulder-joint — compare with hip. Hinge-joints — their nature; examples. Comments on certain ones. Pivot-joints at elbow and base of skull. Gliding-joints. Junctions of ver-

tebræ. Importance of the skeleton. Motion. Animals destitute of skeleton; those with external skeleton; the vertebrates.

Hygiene defined. Infants' bones. Nutrition of bones. Rickets. Scrofula. Rheumatism. Seats. Curvature of spine. Fractures. Sprains.

Alcoholic Drinks.

NOTES FOR TEACHERS.

In all parts of Physiology, teachers will find the interest very much increased by the actual sight of the objects described. This is especially the case with the bones, which are less repulsive to beginners than some other organs, since they are already in some degree familiar objects. The following preparation for the study of bones is suggested.

1. Obtain from a butcher, the day before the lesson, a part of one of the long bones, sawn across, with the marrow in it: the shin of an ox is very suitable, though many others may be substituted. Such fresh portions should be kept moist and cool; *e.g.* in a refrigerator, or under an inverted bowl, or wrapped in a damp cloth. This will show the *solid* or ivory-like part, the *hollow structure* peculiar to long bones, and the *yellow marrow.*

2. The rib of a sheep or other small animal; the adhering flesh should be removed with a knife. This can be held up to the light to show that the *interior is red;* its ends will show some *spongy* tissue, which is red; after noting these points, the bone may be broken in two and its interior further examined. Nos. 1 and 2 should be uncooked.

3. An end of one of the larger bones, as the thigh-bone, of almost any animal, sawn in two lengthwise, displays the *spongy tissue* to great advantage. Either cooked or uncooked will do.

4. The drumstick and other convenient parts of a fowl may be saved, and after standing over night in water may be cleansed of the adhering soft parts, and dried. There is an instructive resemblance between many of these bones and those of man; *e.g.* the "second joint," or thigh; the "drumstick," or tibia and fibula; and also the three large wing-bones,—the humerus, radius, and ulna.

5. Some of the bones of fowls (or larger animals) should be reserved with the *periosteum* and *cartilage* attached. They are easily shown; the cartilage can be cut in slices, and the periosteum stripped off in a

sheet. *Tendons, muscular attachments*, and *fibrous tissue* can be shown at the same time.

6. The leg and wing of boiled fowls supply convenient examples of *joints*. For a larger specimen, the hock-joint of an animal illustrates the hinge principle beautifully.

7. The action of acid on a bone is at first not noticeable; but in the course of half an hour or less bubbles of carbonic acid will be seen covering its surface. (The carbonate of lime, from which this gas proceeds, forms only one-sixth of the mineral substance of bone; *pure* carbonate of lime, in marble or limestone, effervesces very briskly in the same acid, and may interestingly be compared with the bone.) A rib is a suitable bone for this experiment. When made soft, it should be soaked in water, and afterwards preserved in alcohol.

The teacher should, if possible, give some time to inspecting a skeleton before trying to teach its mysteries to pupils. A complete skeleton ought to be in the possession of every large school; but even a partial one is of great service, and a neighboring physician may be able to lend such objects.

Much of the anatomy of bones can be shown upon the living human body. After seeing a single phalanx (finger-bone), or the corresponding bones of cattle, no one can find difficulty in understanding the form and arrangement of similar bones in his own hand. The shape of the lower jaw is easily felt. Such protuberances as the "funny-bone" (olecranon), and the greater trochanter (at the hip-joint), and the spinous processes of the back are readily made out. Ribs and collar-bones are usually easy to trace.

It is suggested that it is more important, as well as more interesting, to know the *uses* of bones than to be able to give their *names*. Particular attention should (for example) be given to the manner in which the skeleton is constructed as a support, — with arches under the feet, an arch (pelvis) at the basis of the spine, and two columns supporting the span of the latter; the rough points and ridges, with the attached fibres, tendons, and flesh, should not pass unheeded; and, as far as may be, ideas should be formed of the way in which the naked skeleton is in life clothed with flesh, and where the internal organs are situated within it.

Teachers wishing to carry this kind of instruction farther than is here indicated, will find valuable aid in Prof. H. P. Bowditch's little work, "Hints for Teachers in Physiology."

CHAPTER III.

THE MUSCLES.

THE muscles are the organs by which movements of the body, or of parts of the body, are produced. They are of two

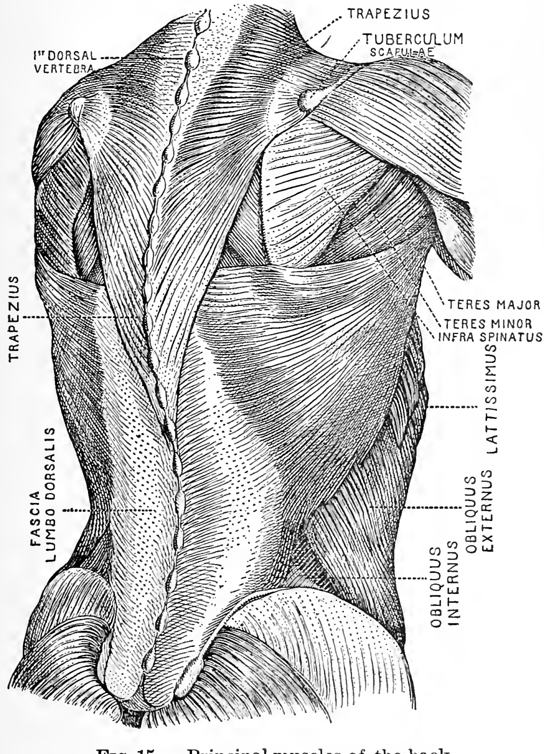


FIG. 15. — Principal muscles of the back.

sorts, — the voluntary and the involuntary. The former are under the control of the will; they are more easily studied, and will be chiefly spoken of here.

VOLUNTARY MUSCLES.

Nearly all the muscles of this class lie quite near the surface of the body. Together with the bones, they compose almost the whole of the limbs; they form a layer over nearly the whole of the trunk; and even the face and skull have many muscles. In thin persons their outlines can often be seen

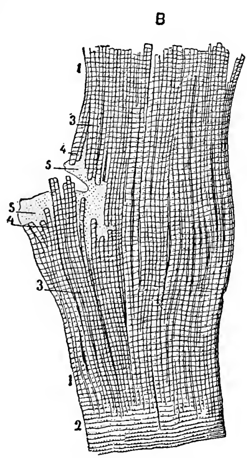


FIG. 16. — A single muscular fibre magnified 250 diameters. The torn sheath is seen at 5, 5. At 1, 1, the striæ (markings) run both lengthwise and across; at 2, only across; 4, is a fibril.

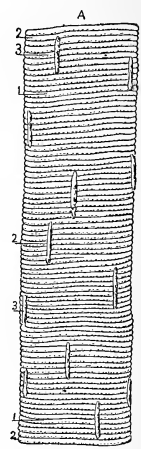


FIG. 17. — Muscular fibre, unbroken. The sheath possesses nuclei at 3, 3, The transverse markings only are seen.

under the skin. In most persons the spaces between the muscles are somewhat filled up with fatty tissue. Fat also forms a layer beneath the skin, veiling the form of the muscles, and giving a rounded outline to the body. The form of the body, however, in general depends so much on the bones and mus-

cles, that artists study them in order to draw the body correctly (Fig. 15).

The muscle itself consists of a mass of red tissue, which in animals is known as flesh, or meat (Figs. 16, 17). Muscles are sometimes attached to the bone directly; but they often have,

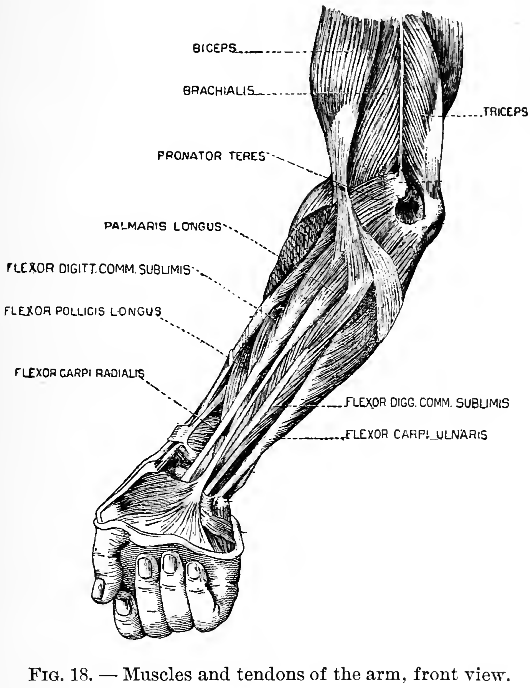


FIG. 18. — Muscles and tendons of the arm, front view.

at one or both ends, a firm, strong, white cord called the *tendon.* In many cases, tendons are quite long; such may be seen about the wrist and the back of the hand, coming clearly into sight when motions are made with the fingers. Those of the ankle are still more conspicuous. The use of such tendons is the same as that of a rope in a sailor's hands; they do not themselves pull, but enable the muscles to give a pull to distant parts.

We can form a fair idea of the appearance of muscles by examining the leg of a fowl, the fleshy part of which is composed of the "bodies" or soft parts of the muscles, while the stringy, uneatable parts are the tendons. A frog's leg with the skin removed gives a still clearer idea. The meat of animals, birds, and fish consists of muscle, its color varying from brown to red, pink, and white. When used as food it may be called flesh-meat, to distinguish it from such parts as the liver, kidneys, or sweetbread.

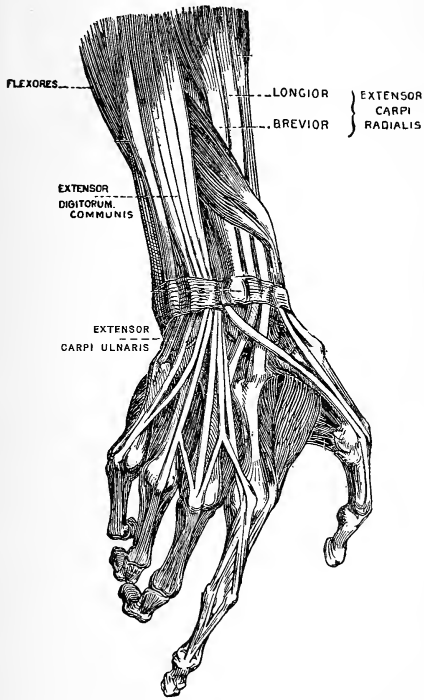


Fig. 19.—Muscles and tendons of the back of the right hand and lower arm.

Muscles of the class here described ("voluntary" muscles) can be seen with the microscope to consist of a great number of fine fibres, laid side by side, each fibre being cross-marked by numerous fine lines (Figs. 16, 17).

PHYSIOLOGY.

If a person opens and shuts his fist vigorously, we can feel the muscles of the forearm move while he does it; we can also see the action of the cords at the wrist, pulling upon the hand. By using a tape-measure, we can prove that the forearm is *larger around* at the moment when the fist is firmly closed, than when it is allowed to remain open without effort. By feeling, we ascertain that the muscle not only swells, but becomes

harder at the moment of effort. Naturally it becomes shortened at the same time, and it is the act of shortening that causes it to pull.

By laying the bare arm on a table and performing slight

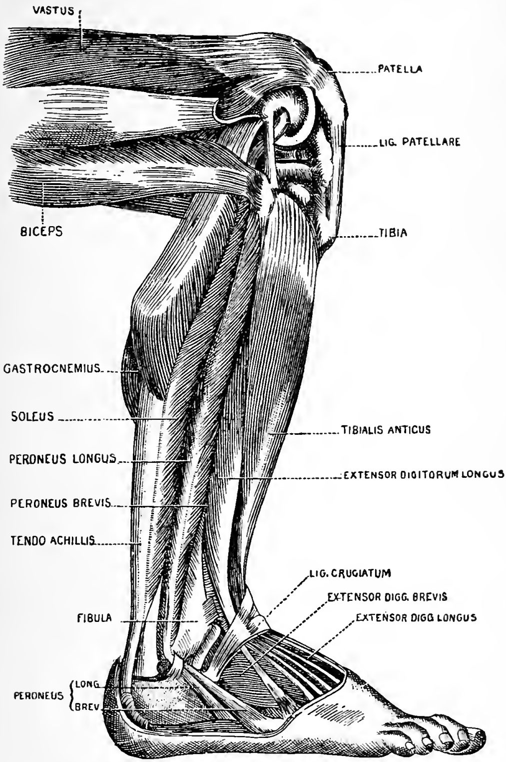


FIG. 20. — Muscles of the knee, leg, and foot.

motions with the fingers, *e.g.* that of gently raising them, one at a time, as if to strike the keys of a piano, we can observe (both by sight and touch) that a part of the forearm may contract while other parts are at rest. This illustrates the fact

that the limb contains a number of muscles of different uses.

One of the largest tendons of the body is found above the heel. Those of the front of the ankle are very easily felt, if, while sitting, we raise the toe, keeping the heel on the floor.

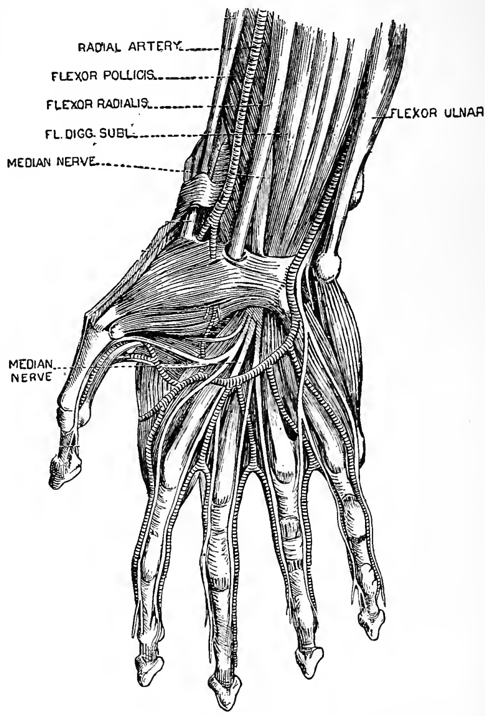


FIG. 21. — Muscles, arteries, and nerves of the front of the right hand.

Most voluntary muscles are attached to two or more bones, and when they act they pull so as to bring the bones nearer together. For example, the biceps of the upper arm is firmly attached to a projecting knob of bone on the radius (one of the bones of the forearm); its upper end is fastened to the shoulder-bones. It pulls in such a way as to bring these two

parts near each other, and in doing so, the hinge-joint at the elbow is bent.

There are, however, some muscles which are not so attached. The mouth is surrounded by a ring of muscle situated in the lips, which when contracted draws or "purses" it up; similar muscles surround the eyes; they are called the orbicularis of the mouth, and the orbicularis of the eye, from the Latin word meaning "circular."

For every motion there is a counter-motion, and for every muscle there is another called its *antagonist,* which acts in the opposite direction. The muscles of one side of the arm bend (flex) the elbow, wrist, and fingers; their antagonists of the other side straighten (extend) them. The same is true of the knees. For raising the arm there is a powerful muscle (the deltoid), which covers the shoulder like a cap; for lowering the arm one might suppose no muscle was needed, since it will fall of its own weight, but by placing the hand in front of the armpit, one can feel the contraction of a powerful muscle (the pectoral) when the hand strikes a quick blow downward. At the rear border of the armpit a similar muscle may be felt.

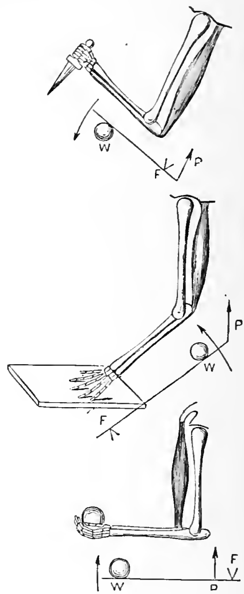


FIG. 22. — The three orders of levers illustrated in the arm. *W* stands for weight; *F*, for fulcrum; *P*, for power. The arrow shows the direction of the action.

The back possesses a great quantity of muscle, which acts in the opposite direction to that of the front part of the trunk.

The action of a muscle involves the principle of the lever. Levers are of three orders, all of which are found in the body. The first order is used in striking with the fist, or a weapon:

the second, in raising the body on the parallel bars; the third, in pulling or lifting.

The first order is also represented by the base of the skull, which is supported or pivoted on the back-bone, and can be drawn down by muscles behind or in front. When the muscles at the back of the neck act, the chin is raised; when those in front act, the head is bowed forward.

The second order is seen at the heel. The weight of the body, in standing, is supported on the ankle; if the person stand on his toes, he has to raise his own weight an inch or two from the ground, which is done by a pull from the rear. In the diagram the elbow acts like the heel.

PRINCIPAL USES OF THE VOLUNTARY MUSCLES.

1. **Locomotion and Work.** — Locomotion is moving from one place to another. It includes such acts as walking, creeping, swimming, diving, flying, climbing, running, jumping; bringing into play most or all of the voluntary muscles of the trunk and limbs. Work includes useful acts, such as lifting, carrying, using tools, writing, playing musical instruments, and the like.

2. **Breathing.** — Many large muscles are used in breathing; they will be described elsewhere. Their work is immensely important, since life and speech depend on them.

3. **Speech.** — The voice is formed by the action of the chest, throat, larynx, mouth, and nose, all of which are furnished with muscles that have the power of changing the shape of these parts. The tongue is a mass of muscle, and the lips are muscular. Weakness (from disease, cold, hunger or thirst, paralysis, etc.) affects the power of these muscles and therefore changes the tone of the voice.

4. **Eye.** — The eyes are moved in their sockets, to look in the directions required, by several little muscles. Paralysis from disease of the brain affects them; so does intoxication.

5. **Ear.** — The movements of the outer ear are unimpor-

tant in man, though prominent in lower animals. The middle ear (behind the drum) contains little muscles attached to the small bones.

6. **Expression.** — Many parts of the face are provided with

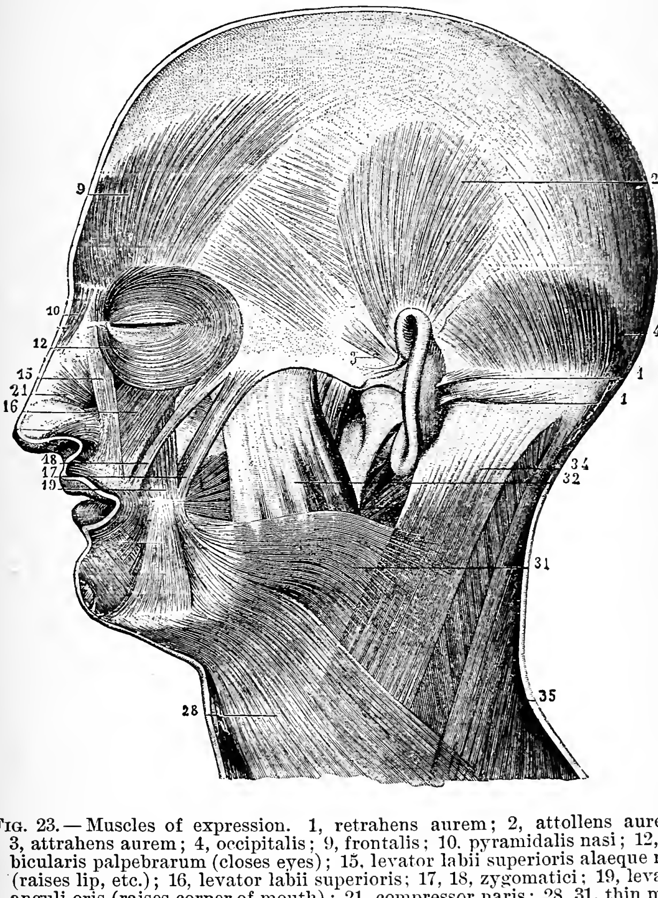


Fig. 23. — Muscles of expression. 1, retrahens aurem; 2, attollens aurem; 3, attrahens aurem; 4, occipitalis; 9, frontalis; 10. pyramidalis nasi; 12, orbicularis palpebrarum (closes eyes); 15. levator labii superioris alaeque nasi (raises lip, etc.); 16, levator labii superioris; 17, 18, zygomatici; 19, levator anguli oris (raises corner of mouth); 21, compressor naris; 28, 31, thin muscles under the skin of the neck; 32, masseter (chewing); 34, sterno-mastoid (bowing); 35, trapezius. The circular fibres around the mouth close it.

little muscles below the skin which pull the face in different directions. They are set in action by feelings or emotions. Some draw the corners of the mouth up in smiling; some draw them down in sorrow; others wrinkle the forehead in anger or suspicion; others give a humorous look to the corners of the eye. These motions are usually made without our knowledge; they are then spontaneous or involuntary. But we can by practice learn to perform them, so as to appear to feel in various ways, as actors can do; or we can learn to check them so as to hide our real feelings, which is much harder.

The classes of actions thus far described are mostly under the control of the will. We can perform them when we choose, and refrain when we choose. The muscles which perform them are called "the organs of the will," and are the agents by which one class of persons do good deeds, and another class do evil. We are therefore morally and religiously responsible for the uses to which we put these muscles.

INVOLUNTARY MUSCLES.

The act of swallowing begins by pushing the food back with the tongue. When it is beyond the tongue, the muscles of the upper throat squeeze it into the gullet. These actions are voluntary, though it is a remarkable fact that we can seldom perform them unless we have something in the mouth to swallow.

The gullet is a long tube reaching to the stomach. It is lined with a smooth sort of skin, somewhat like that of the inside of the mouth (mucous membrane); it has also, all the way down, a thin, outer layer of muscles going round it circularly, which begin to contract and squeeze, one after the other, as soon as anything enters the upper part of the gullet. Thus the food is pushed or squeezed down into the stomach. We do not feel these muscles act, and we cannot make them work by trying to do so. They are independent of the will, or *involuntary*.

The same sort of muscles form a coating over the stomach and the intestines, and cause the food, once swallowed, to travel slowly onward.

They are also found in the veins and arteries.

They are different in appearance from voluntary muscles. As shown in Fig. 24, they are composed of very long fibres, tapering at the ends; a common name is *smooth, or unstriped, muscular fibre.* The fibres of voluntary muscles are shown by the microscope (Fig. 16) to be marked by a very great number of cross-stripes. The heart is composed of the latter sort, though it is not controlled by the will.

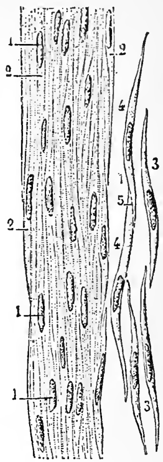


Fig. 24. — Involuntary muscle. 1, 1, nuclei of the fibres; 2, 3, fibres; 4, 5, two fibres joined.

HYGIENE OF THE MUSCLES.

One of the most remarkable things about muscle is the way it increases by being used, and shrinks when not used. If a broken arm is put up in splints and kept immovable for some weeks, it will be found at the end of that time, when the splints are removed, that the arm, though not diseased, is almost paralyzed; the owner of it has to exercise it until the power of moving it has been regained. And on the other hand, we all know how readily we can increase both the power and the size of the muscle of the arm by using dumb-bells.

The muscles of an infant, like its bones, are weak; yet we see that it is constantly moving them, opening and shutting its fingers and toes, moving its arms and legs in odd ways. As it grows older, its powers increase; it first creeps, then, when its leg-bones are strong, it walks. Later, at the age of three or four, it becomes so fond of running that a grown person who should try to keep up with it would be tired.

This is the natural way for children to grow strong, and it is wrong to prevent them from having the opportunity.

For children and young people, certainly up to the age of full growth, running is one of the best exercises, and all who have the strength should play running games. One chief benefit from running is that which is felt by the lungs; "the wind" is improved. Another consists in strengthening the power of the heart, which is needed in order to make the blood flow strongly and freely.

A child needs several hours of play daily; a person from fourteen to eighteen had better have two hours of play on the feet, or of walking, each day.

"Exercise" is beneficial in several ways:—

1. It gives a good appetite, and prevents trouble in the stomach, such as lazy people are apt to suffer from.

2. It thus enables us to take more nourishment, which is very useful for the growing body of a child, making all parts stronger and healthier.

3. It promotes good humor and improves the power of study.

4. Properly conducted exercise, by strengthening the muscles of the back, will prevent and even cure the disease called lateral (*i.e.* sideways) curvature of the spine. But ordinary play, however useful in some respects, will not always give a person a "straight back." There is much play that is one-sided; for example, pitching ball with one hand, which sometimes makes a boy's body grow irregularly. When one shoulder is higher than the other, or "grows out," there is danger of curved spine. A great many girls and but few boys have this deformity; the reason of this difference is the fact that very few girls, from the age of twelve up, take the exercise they require, while most boys do get in play something like what they need.

5. Exercise ought to develop the chest. Ordinary play does not do this to any great extent; it strengthens the legs, but leaves the arms, back, and chest comparatively weak. Climbing, swimming, boxing, rowing, and gymnastics remedy this.

A good-sized chest is one of the most important things for a person who wishes to be healthy. Most consumptive people have weak and small chests, and many a person might prolong his life by training himself so as to remedy this defect. But weakly persons ought to take the advice of experienced physicians or trainers before beginning exercise, as they may otherwise put themselves in danger.

6. A person who has been regularly trained in bodily exercises is pretty sure, when grown up, to be able to do more work in his profession or business than he could otherwise have done. He becomes stronger "all round."

7. A great deal of vice can be prevented by steady habits of vigorous exercise in good company.

The body is usually strongest and most able to take exercise in the forenoon. The morning, before breakfast, is enjoyed by some for walking and other exercise, but many cannot exercise at that time without feeling much fatigue, which is of a weakening sort.

Exercise does us most good when it makes us breathe more quickly and fully than usual, and when it starts the perspiration. It is plain that during exercise no tight clothing should be worn; such articles are not only uncomfortable, but even dangerous. Especially the neck, chest, and waist must be very loosely clad.

Exercise should, as a rule, leave us feeling *moderately* fatigued. It is unsafe to eat a meal directly after making severe exertion; the stomach is capable of feeling the fatigue of such exertion, and if food is then taken the stomach has no power to digest it, and severe illness may follow. Rest before eating is proper when one is greatly tired.

After a hearty meal, very little exercise should be taken for some time.

It is much better to exercise in the open air when possible, and when exercising in a room we should open windows more or less.

Excitement of mind is apt to set the muscles in motion;

some people, even in ordinary conversation, feel compelled to make motions with the hands, called gestures, — "to let off steam," as it were. This is more natural to the Italians or French than to us, and more to us than to the English. In a violent passion some persons' muscles seem to run away with them; the arms fly about, the feet stamp, and blows or scratches are given almost unconsciously. Such men are like drivers who let their horses "get away with them." The habit of getting into a rage is very hurtful to children; it weakens the nerves, and tends to produce the dreadful disease, epilepsy.

STIMULANTS AND NARCOTICS.

It might be thought that a "stimulant" would make a man's muscles stronger for a short time, but this is not so. A person who can lift a hundred pounds may take a drink of spirit, wine, or beer, and in a few minutes he may *feel* stronger than before; but he will not be able to lift any more, in reality.

Before a boat-race, or a foot-race, or a prize-fight, men are "trained" for some weeks so as to make them strong and enduring. They run, walk, box, use gymnastics. (If their chests are small, they are not allowed to make the attempt.) They rise early, go to bed early, eat regularly of wholesome food; and if they have been accustomed to use alcoholic drinks, they are obliged either to give them up altogether, or to take very little. Tobacco, also, is either given up by men in training, or is used in small amounts.

Practical experience, therefore, shows that alcoholic drinks do not help a man to grow strong. Much less do they help a boy.

When an excess is taken, the muscles become partly paralyzed for a time. People show this in various ways. Most will "talk thick," owing to a partial paralysis of the muscles of the tongue and mouth. There is an inability to control the movements of the eyes. The hand is unsteady. The legs are

weakened, the body totters; and in complete intoxication the whole person is "as limp as a wet rag." Old drinkers are apt to have trembling hands.

Tobacco, taken by a person not used to it, makes him feel utterly weak and prostrate. Boys who become accustomed to it are often sluggish, and show a lack of desire for play and exercise, which is most unnatural and unwholesome. A healthy boy wants to be much on the move, and anything which makes him feel otherwise is contrary to the right principles of his bodily nature.

Tea, coffee, cocoa, which are so useful in many cases, are capable, when used by certain persons, of causing the muscles to twitch or tremble. This is more common with people who take no exercise. Such effects are signs that the system is being slowly poisoned.

SYNOPSIS.

Voluntary Muscles lie near the surface, and form the chief part of the limbs. Their outlines form a large part of the outlines of the body. They are usually attached to bones, and by pulling on the bones cause the movements of the body. The muscular tissue is the substance called meat. Its fibres are marked with fine cross-lines. Muscles usually end in cords or tendons, which attach them to bones.

The muscles are enabled to give a pull by the change of shape which they undergo, — swelling in the transverse direction and shortening in the longitudinal. They grow harder at the same time. Some muscles are not attached to bone: that which forms a ring around the mouth is an instance.

Each muscle has an antagonist, which moves the joint or limb in an opposite direction. Examples are seen in the limbs.

The three orders of levers are represented in the body by the different arrangement of the muscles in connection with the joints.

The voluntary muscles are the means of performing a great variety of actions, including locomotion or movement from place to place, useful labor, breathing, speech; they assist in sight and hearing; they cause the face to take various expressions.

Involuntary Muscles are of a different appearance from the

former class. The fibres (except in the heart) have no cross-markings. They act upon the parts which receive and digest food, beginning at the point where the food enters the throat. Swallowing is a voluntary act only at its beginning. They are also found in the veins and arteries.

Muscles grow larger by being much used, and shrink when disused. They are very weak in infants, and develop very gradually by very frequent motion and by play. Exercise is useful in several ways: it increases appetite, makes the stomach healthy, increases the amount of food consumed, promotes good humor, clears the mental powers; it prevents deformities, if properly regulated; it develops the size of the chest, improves the wind, and strengthens the power of the heart, so that a person is better able to do vigorous athletic work; it tends also to prevent chest disease; it gives a power to do more work in business; it tends to prevent vice.

Exercise should not be taken at times when the body is weak or tired; not much of it just before or after eating. It should be taken in pure air.

Alcoholic drinks do not increase muscular power. They are not useful to persons who are training themselves for athletic contests.

An excess of alcoholic drink causes partial paralysis of the muscles, and in some cases leads to trembling of the muscles.

Tobacco makes some persons sluggish and disinclined to take exercise.

Tea, coffee, cocoa, may cause twitching of the muscles.

SUGGESTED QUESTIONS.

Two classes of muscles. Voluntary muscles, where found. Outlines of the body. Action of muscles on the bones. Tendons: appearance; use; examples. Muscles: general appearance; microscopic appearance; color; examples.

Contraction of the muscles; experimental illustrations. Separate muscles in arm. Examples of tendons. Muscles unattached to bone. Antagonism; examples. Levers: three orders; examples.

Uses of muscles. Locomotion and work; breathing; speech, organs of, weakness of; sight; hearing; expression of feeling. Moral responsibility.

Involuntary muscles; appearance. Swallowing, mixture of volun-

tary and involuntary acts. Coating of the digestive tract; use. Blood-vessels.

Effect of use and disuse. Splints. Infants. Play. Running. Uses of exercise: digestion; nourishment; mental state; form of the body, chest, heart, lungs; general powers; good habits. Points connected with exercise: time; clothing; amount of exertion; meals; rest; air. Excitement.

Stimulants: effect on muscular exercise; in fatigue and chilliness; in training. Paralysis. Tremor.

Tobacco. Tea and similar drinks.

NOTES FOR TEACHERS.

It may not seem desirable to exhibit *food* before a class as an object of anatomical study. It is well to know that very interesting views of muscles can be had by simply removing the skin from the body of any bird which may have been shot as injurious to the crops or as a nuisance. The feathers of the breast being parted, a single cut (carefully directed) with a pointed knife along the middle line of front of the body is nearly all that need be done with instruments. The skin can be removed with the fingers very easily. The pectorals are remarkably large and dark colored in flying birds, though white in chickens. The muscles of the arm (wing) and leg are easily exposed, and present considerable general resemblance to those of the human body. By pulling on the pectorals and on certain arm-muscles, several movements of the wings and feathers can be imitated.

The resemblance of a frog's leg to that of the human subject is closer than in the case of a bird.

In neither case is any dissection, properly speaking, required to give a general view of muscles.

CHAPTER IV.

CIRCULATION AND RESPIRATION.

THE BLOOD.

This substance, which is estimated to compose one-thirteenth of the human body, by weight, is a mixture of different substances, — *serum*, which is a fluid; *fibrin*, which is fluid in the body, but solidifies when the blood is taken from the body; and with these two, which are fluid in our systems, there is mingled an immense number of minute *blood-cor'puscles*, or blood-cells, of two kinds.

Blood freshly drawn from an animal and set aside in a glass vessel soon becomes a red, jelly-like mass. This change is called *coagulation*.

If we let the coagulated blood stand, it gradually separates into two parts, — a light yellow liquid, consisting of serum colored by a few blood-cells, and a compact, semi-solid mass, the *clot*, which contains the solidified fibrin with the great part of the blood-cells. The clot is red; darker below and lighter at top.

The blood is the *nourisher* of the body; and its different parts are each nutritious. The serum contains a considerable amount of albu'min (see "Food"). The fibrin and the blood-cells closely resemble the material which composes flesh, or muscle. Besides these, blood contains such mineral substances as are found in the body. Blood is, in fact, composed of nearly the same ingredients as milk, though in different proportions. It is so nearly like muscle in its chemical composition, that a distinguished French physiologist named it "liquid flesh."

Certain other substances exist in the blood, which may be called the *waste-products* of the system, or materials which come from the using-up of the tissues of the body. The same liquid, therefore, which carries food to the parts, also takes off the waste or sewage matters from the parts. These matters are chiefly carried to the sweat-glands, to the kidneys, and to the lungs, each of which excretes (or sends off) waste-matter mixed with large quantities of water.

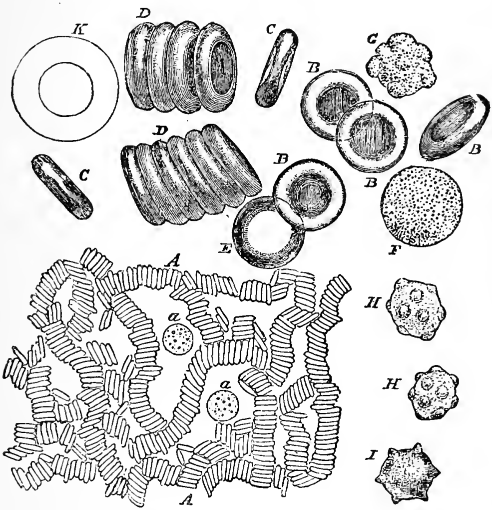


FIG. 25.—Red and white corpuscles of the blood, magnified. *A*, moderately magnified. The red ones are lying in rolls, like coin; there are two white ones at *a* and *a*. *B*, *C*, *D*, red corpuscles in various positions, much more enlarged; *E*, one swollen to a sphere; *F*, *G*, white corpuscles; *H*, *I*, unusual forms of red corpuscles; *K*, the red, treated with acetic acid.

The blood is of the utmost importance in sustaining life, whether it be of the whole body or of a part. If an arm or a leg is tied in such a way that the blood cannot get into it, the limb grows cold, and will gradually perish if kept tied. If the greater part of the blood is taken from a person's body, extreme weakness follows, and then death. On the other

hand, if blood, properly prepared to prevent clotting, is thrown into the veins of the tied limb, and is kept flowing in, the life of the part is preserved. And similarly, when a person has bled a great deal, and is in danger of dying, fresh, warm blood from another person, or from a sheep, has sometimes been put into the veins, and has saved life. This is called *transfusion of blood.*

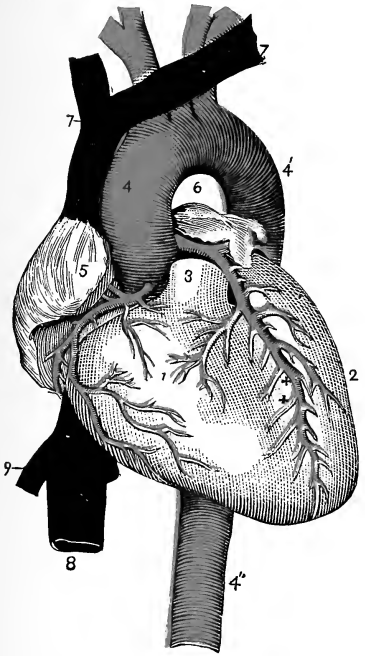


Fig. 26. — The heart and large blood-vessels, in front. 1, right ventricle; 2, left ventricle; 3, pulmonary artery, cut short; 4, 4′, 4″, aorta, or chief artery; 5, 6, parts of the right and left auricle; 7, 7, veins uniting to form the superior (upper) vena cava; 8, inferior vena cava; 9, vein from liver; +, arteries nourishing the heart.

The red color of the blood is due entirely to the *red blood-corpuscles* or *blood-cells.* These are soft, pulpy masses, shaped like round, flat cakes, sometimes lying separate, sometimes clinging together in rolls, like piles of coin. They are so small as to require rather a strong microscope to show them. There are millions in a single drop of blood, and more than ten millions could lie side by side on a surface one inch square.

In pale, feeble persons, there are usually too few red blood-cells. Iron is often given to such persons as a medicine. Iron is the cause of the red color of the blood-cells, and when taken as a medicine it may increase the number of them.

Among several hundred of these corpuscles there is usually one white cell, a round clump of material, very different from

the red. It is believed that the white kind changes into the red.

THE MOVEMENT OF THE BLOOD.

The blood is not contained in the body as water is in a sponge. It is contained in a vast number of large and small tubes called *blood-vessels,* and in the heart, which is the central point of the whole. The blood-vessels include *arteries, veins,* and *cap'illaries.*

The capillaries are too small to be seen with the naked eye. Veins are easily seen on the arm and back of the hand. Arteries are smaller than veins, and do not show so plainly, but by examining the front of the wrist, and the temples, we may sometimes see or feel them beating. This beating, called the *pulse,* is a sign that the blood is moving; and the movement of the blood, beginning at the heart, and going through arteries, capillaries, and veins, and then back again to the heart, is the *circulation.*

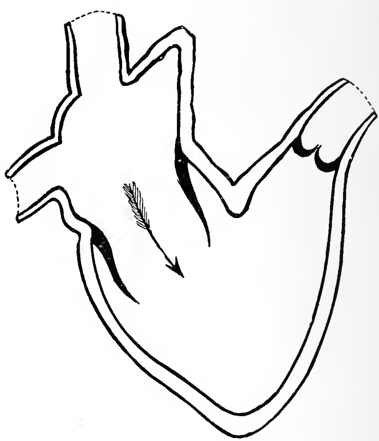


FIG. 27.—Diagram of the heart, with blood flowing *in* where the arrow is placed, from the upper cavity (auricle) to the lower (ventricle). The large valve is open; the small one closed.

Heart and Arteries.— The heart is about as large as the fist of the person it belongs to. It lies in the chest, a little to the left of the middle, between the two lungs. It is hollow, to contain blood; it is composed chiefly of muscle, which works as a person's hand does in squeezing. It is a kind of little force-pump, so made that when it closes, or "contracts," it

pushes out a stream of blood into the great artery (*aor'ta*). In contracting, the heart changes shape a little, and its lower end strikes against the wall of the chest below the left breast, where it may be felt beating. The aorta, always full of blood, is distended by the blood pushed into it; and a kind of wave of fulness travels quickly along the whole length of the aorta, and into its branches, large and small. Each part of every artery swells for an instant when the wave comes. This swelling can be felt and seen, and is called the pulse. If an artery is cut, the blood can be seen spurting out in regular jets, one at each pulse-beat.

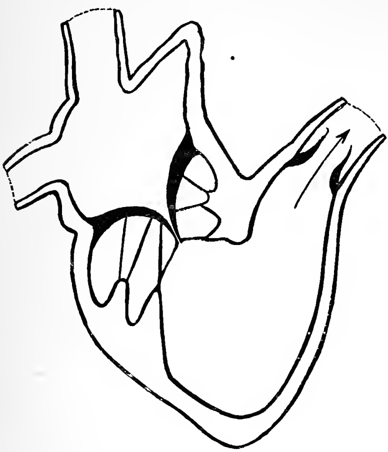


FIG. 28.—The same, having become full, and contracting to force the blood *out* by the passage shown by the arrow.

Capillaries.—The smallest arteries divide up into a meshwork of still smaller blood-vessels, called capillary vessels, or capillaries, from their small size.[1] They have no pulse. The walls of the capillaries are thin, and fluid easily passes through to the tissues around them; and it is thus that the nourishment reaches the muscles, bones, and all other parts which require it. Capillaries are found almost everywhere. It is they which bleed when a pin is thrust into the skin. In the stomach and intestines they have much work to do, both in supplying material to the glands, to form gastric juice and other secretions, and in receiving the digested food. They are found in connection with all the glands.

Veins.—While passing through the capillaries, the blood

[1] From the Latin *capillus*, a hair; "hair-tubes."

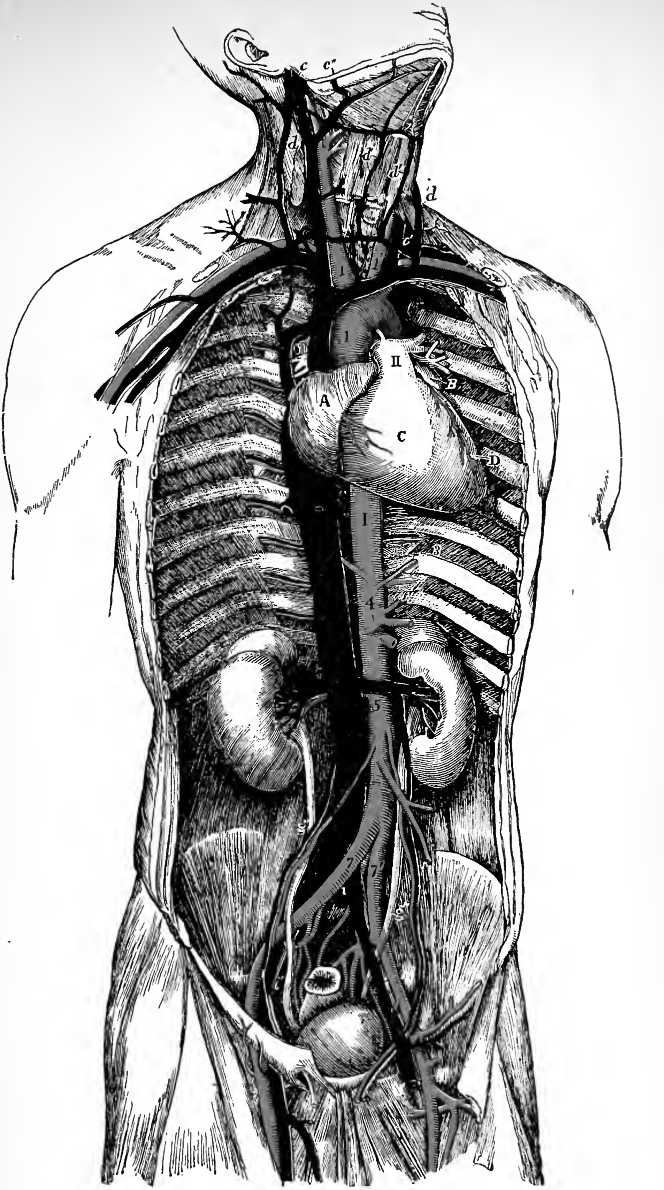


Fig. 29. – Heart and blood-vessels of the trunk. *A*, right auricle; *B*, part of left auricle; *C*, right ventricle; *D*, part of left ventricle; *I*, *I*, aorta; *II*, pulmonary artery; *III*, superior, and *IV*, inferior, vena cava; 1, 1, carotid arteries; 4, arteries for diaphragm: 5, for kidney: 7, 7′, for the legs; *a*, *a′*, veins uniting to form the superior vena cava; *c*, *c′*, internal jugular veins; *c″*, facial vein; *d*, *d*, external jugular veins; *f*, veins from liver; *g*, from kidney; *i*, etc., from lower limbs.

loses much of its valuable nutritive material, and also receives some of the waste or used-up material from the parts it has traversed. In doing this it changes its color. In the arteries it is bright red; in the veins, a dark red. If a vein is cut, the blood flows in a steady stream, not by jerks; the vein has no pulse. The walls of a vein are softer than those of an artery,

FIG. 30.—**Part of the web of a frog's foot, slightly magnified, the blood-vessels only being drawn, except in one corner, where pigment spots are also shown.** *a*, **small arteries;** *v*, **small veins; the capillaries are the minute tubes joining the veins and arteries. The arrows show the direction of the current.**

and can easily be pressed together so as to stop the flow of blood. To illustrate the circulation in the veins, tie a handkerchief firmly around the arm near the elbow: the veins will

at once swell, displaying a network of bluish lines just under the skin of the forearm and hand. This shows that the current in these veins flows from the hand towards the shoulder; for if it were the other way, stopping the veins would make them swell above the bandage. The arteries mostly lie deeper than the veins, and their walls are firmer, so that a moderate pressure has very little effect on them: they keep on pouring blood into the lower arm until the vessels can hold no more, and the arm is perceptibly swollen.

The veins are provided with *valves*, arranged at short distances apart, which keep the blood from flowing the wrong way. In the arm these valves are arranged so as to let the current pass freely towards the shoulder and trunk. If we hold the hand up above the head, we can see the veins shrink as the blood sinks downward, or, as it were, drains away from the arm — which would not occur if the valves opposed it.

The following experiment further shows the action of the valves: Place the tip of the middle finger lightly and steadily on one of the large veins near the knuckles of the other hand.

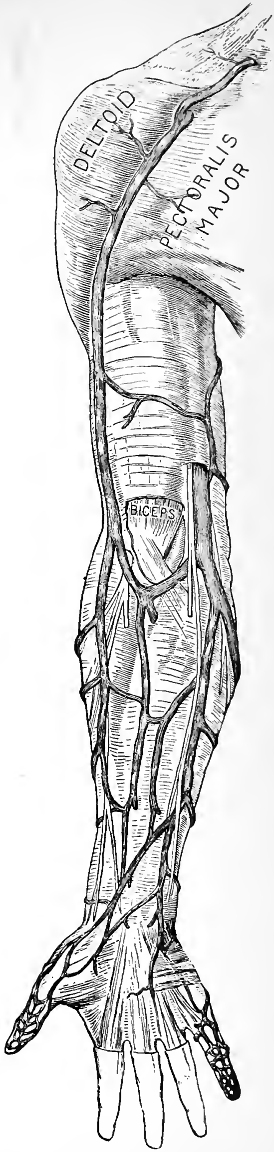


Fig. 31. — The veins lying near the surface of the arm. A few nerves are seen accompanying the veins. The skin is removed, but the fibrous sheath covering most of the muscles is left remaining.

With the forefinger then stroke the vein so as to push the blood from a portion of it, keeping the middle finger in place; the vein remains empty for a length of an inch or two from the middle finger. Lift the forefinger, and no blood enters the vein: there is a valve towards the wrist which holds it back. Lift the middle finger, and the vein fills instantly.[1]

Pulmonary Circulation. — The heart has just been described as a pump which forces the blood through the body. If we now proceed to examine its inner structure, studying the

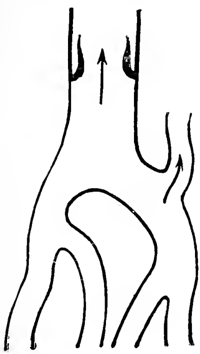


FIG. 32. — Diagram of several veins united, the current flowing upward, the valve open.

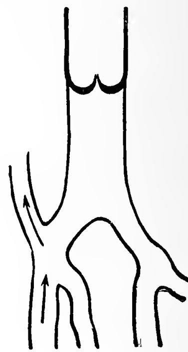


FIG. 33. — The same, when the valve is closed, owing to an obstruction at a higher point. Here the current continues to flow, but seeks a side channel which is free.

arrangement of its valves and pipes, we find that it is a *double* pump. It apparently forms one organ; but it has a right and a left side, completely independent of one another. The use made of this curious plan is as follows. The right side (or pump) forces blood into the lungs, where it is purified; then the blood flows back to the heart, where the left side (or pump) receives it, and forces it through the arteries, capil-

[1] For experiments on veins, select persons with large veins; adults, rather than children.

laries, and veins, as has already been described. The latter is called the *general* circulation; it carries out pure blood to the body, and brings back impure blood to the heart. The passage through the lungs is called the *pulmonary* circulation; it carries impure blood to the lungs, and brings back pure blood to the heart.

Figs. 27 and 28 will answer equally well for either side of the heart, as both sides are constructed on the same plan. The heart is furnished with four sets of valves, the use of which is like that of ordinary pump-valves. One is placed at each of the points of discharge (pulmonary artery, aorta), opening outward. They keep the blood from flowing back into the heart after it has been forced out. The other two are placed between the auricle and the ventricle, on each side: they keep the blood from flowing back from ventricle to auricle. The student will find in Fig. 27 a sufficient illustration of the meaning of the terms "auricle" and "ventricle." The figure stands for either side of the heart.

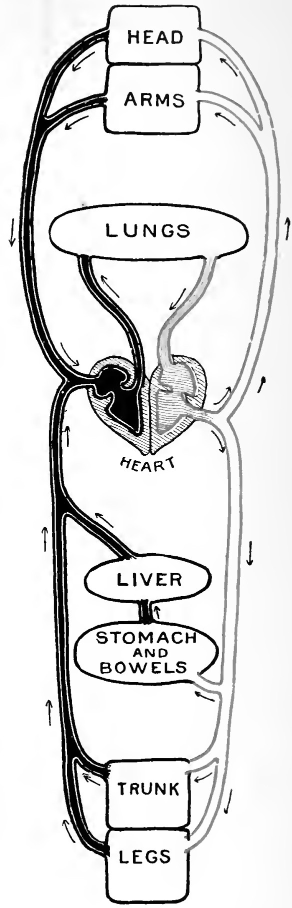


FIG. 34. — Diagram of circulation. The arrows indicate the direction of the flow. Arterial blood, red; venous blood, blue.

Hepat'ic Circulation. — A third system of circulation is that which passes through the *liver* (Fig. 34). The capillaries of the digestive tract (*i.e.* of the stomach and intestines) contain blood which is rich in the nutritive materials derived from the digestion of food. These capillaries unite, forming a large and important vessel, the *portal vein*, which enters the liver, and there again subdivides into capillaries. The load of nutriment contained in this blood is chemically acted upon by the liver. Then, passing out from the liver by several large veins, the food-bearing blood enters the lower vena cava, or great vein which discharges directly into the right side of the heart. Thus it enters the great mass of the blood. In a moment more it passes on to the lungs, where fresh oxygen is supplied to complete the chemical changes it must undergo.

FIG. 35. — Valves of a lymphatic vessel.

THE LYMPHATIC CIRCULATION.

Outside of the blood-vessels there is a great amount of tissue of various sorts. It will easily be understood that in this, tissue fluid of some sort or another must exist in abundance. If by any means the blood-vessels could be prevented from bleeding, and a cut were made in the body, a fluid would still be dis-

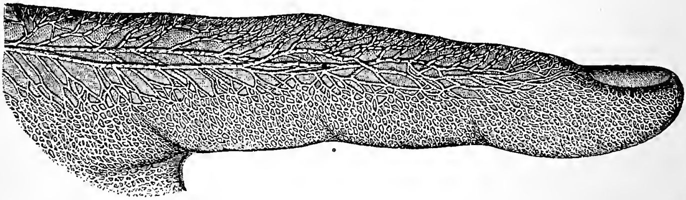


FIG. 36. — Lymphatic vessels of the surface of a finger. In the preparation, the skin was dried and varnished, and the vessels appeared through the skin.

charged from the wound. This fluid is called the *lymph*. It is clear and colorless. It fills interstices and pores innumerable, in almost all parts of the body. It does not remain still and stagnant in the parts where it happens to be, but is in constant motion.

There is a set of very small vessels (the *lymphatics*), somewhat resembling little veins, whose duty is to take up the lymph and convey it towards a spot where it is discharged into the general circulation of the blood. Fig. 35 shows the valve-structure of one of the lymphatic vessels. Fig. 36 shows how numerous they are, and exhibits the way in which the smaller ones unite to form larger trunks as they run up the finger. In Fig. 37 the arrangement for the surface of an arm is shown, and with it are displayed some of the *lymphatic glands*. The latter are small rounded bodies, through which the lymph has to pass, and in passing is acted on and changed in some way by the gland.

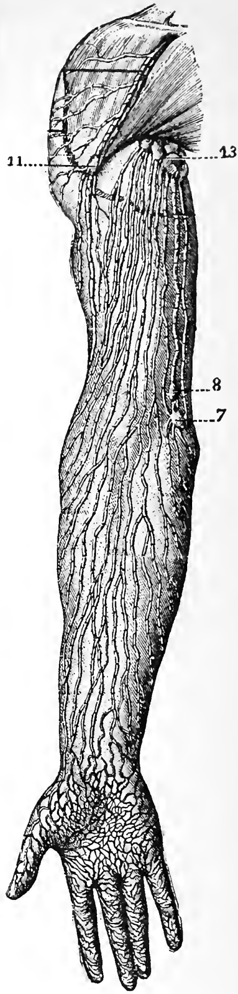


FIG. 37.—Lymphatic vessels of the surface of the arm. Glands are seen at 7, 8, 11, 13.

All the lymphatic vessels unite finally in two large ones, situated inside of the trunk, and these discharge into the great blood-vessels at the upper part, near the neck; their contents are then taken rapidly into the heart, and at once form a part of the blood.

There is no special arrangement for making the lymph circulate. It moves whenever a part of the body is raised,

or pressed, or shaken, or when the muscles act; all these cause some pressure on the lymphatics, and since the vessels allow motion in only one direction, some of the fluid is constantly moving upward, or toward the central parts of the body.

Great numbers of the lymphatics begin in the walls of the intestines, where their function is to take up certain nutritive

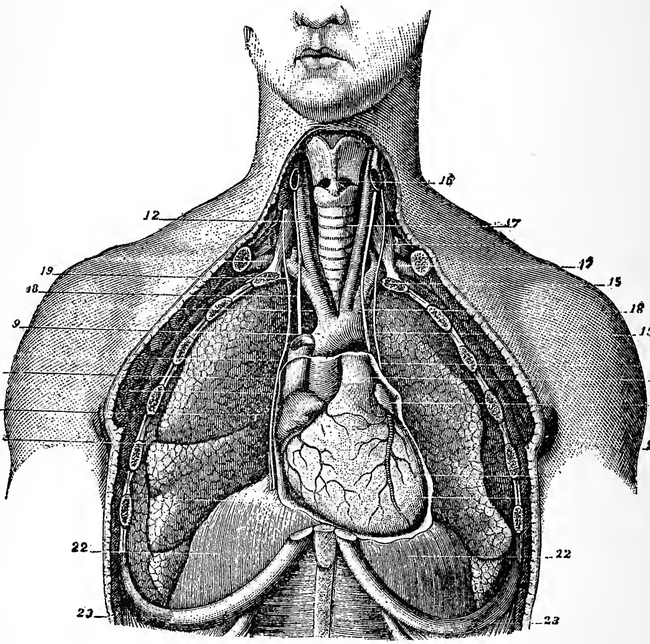


Fig. 38. — The heart and lungs; the latter thrown back at the sides. The heart is seen in its envelope, or pericardium, which is opened. 4, left; 5, right auricle; 6, vena cava superior; 7, pulmonary artery; 9, aorta; 12, carotid artery; 15, first rib; 16, larynx; 17, trachea; 18, nerve to lungs and stomach; 19, nerve to diaphragm; 20, lung; 22, diaphragm; 23, seventh rib.

materials (the fatty substances) and convey them to the blood, — as will be further explained in the chapter on "Food and Digestion."

OXYGENATION.

The space in the chest which is not occupied by the heart is filled by the lungs, which during life are constantly taking air in and sending it out. The air, entering by the nostrils or

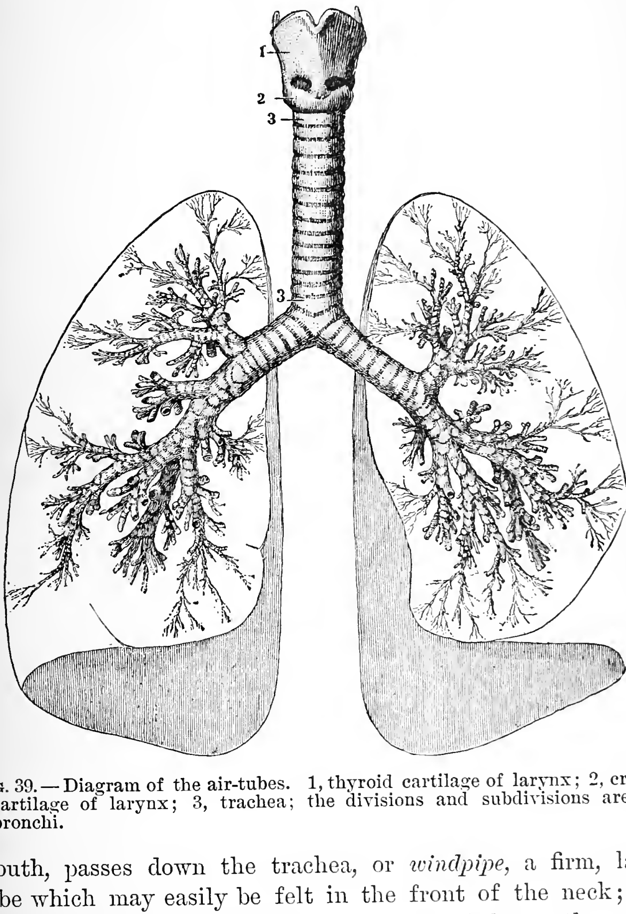


Fig. 39.— Diagram of the air-tubes. 1, thyroid cartilage of larynx; 2, cricoid cartilage of larynx; 3, trachea; the divisions and subdivisions are the bronchi.

mouth, passes down the trachea, or *windpipe*, a firm, large tube which may easily be felt in the front of the neck; the windpipe divides into two parts, one for each lung; these sub-

divide, in the lungs, into smaller tubes called *bronchial tubes,* which after much branching end in very small cavities or *ves'icles.* These vesicles have very thin walls, and close behind their walls, networks of capillaries, containing blood which requires to be purified.

About one-fifth of the air we breathe is oxygen gas, an invisible, tasteless, and odorless substance, which we could not tell from common air by ordinary means, if it were put before us in a pure state. Oxygen, however, is the part of air which supports life. Air deprived of it could be breathed, but a person would die in such air as soon as if he were under water. This oxygen has the power of passing through the thin walls of the vesicles and those of the capillaries; and having done so, it is at once absorbed by the red corpuscles, whose duty it is to carry it all over the body for use at all points. When it comes to any place where it is needed, it leaves the blood-cells just as quickly as it went to them in the lungs. "Oxygenation" is the process of supplying the blood and tissues with oxygen.

The use of oxygen, in all the parts to which it is carried, is to unite with the materials of the parts and change them. This change is called oxidation. It is the same that occurs outside of the body in burning. But combustion, or burning, often goes on so slowly that no flame and but little heat is produced. It is this slow oxidation that occurs in the body. Something like it may be seen when a pile of compost, a heap of sawdust, or a few greasy rags thrown together,[1] grow hot, and smoke, when left to themselves.

To see how a thing may burn without being destroyed at all, look at a fresh candle-wick or lamp-wick when lighted. It soaks up the wax or the oil, and makes that burn, while itself hardly changes color. This is a good example of some things which occur in the body. A muscle, for instance, while at work, takes much nutritious material from the blood and burns it in a quiet way, without flame; the muscle, after work-

[1] **N.B. — Such heaps of rags or sawdust may blaze, and set buildings on fire.**

ing, looks as before, though it is warmer, and the blood which has passed through it is warmer than before.

The materials burned in the body are such as could be burned in a stove. For instance, it would be possible to build a fire of bread, dried fruit, or even dried meat, while fat burns very readily. If burnt in this way, these bodies change to three substances, principally, — water, carbonic acid gas, and the nitrogenous substance called urea.

The same substances are produced when the materials of the body are consumed in vital processes. They are easily absorbed or dissolved by the blood. When much carbonic acid has been taken up, and much oxygen lost, by the blood, its color becomes dark, and it requires to be purified in the lungs by discharging its carbonic acid and taking in a fresh stock of oxygen.

The fact that combustion occurs in the body shows that food can be considered as a fuel, or a means of keeping the body warm.

TEMPERATURE OF THE BODY.

The temperature of a healthy man's body is very nearly 99° F. It varies a fraction of a degree from hour to hour; and exercise increases it a little. In fever, it rises several degrees.

The bulb of a thermometer, placed on the skin, will usually register a much lower temperature than 99°. The skin, therefore, is usually much cooler than the interior parts; in fact, one of its functions is to cool the body, — throwing off a part of the heat which is being produced all the time, and which, if accumulated in the body, would become so great as to destroy life.

Perspiration has a great effect in cooling the skin. In fact, when the thermometer stands at 99° or higher, if the skin does not perspire, the body will quickly grow hot and feverish; while this degree of heat is easily borne by a person whose body perspires naturally.

It may be asked why it is necessary for the body to produce so much heat which it is obliged to get rid of. The question is especially interesting in hot weather. A good general answer is this: that the chemistry of the interior of the body cannot be carried on at a lower temperature, in man. Fishes, reptiles, and frogs have a much lower temperature; they are "cold-blooded" creatures.

Blushing (or flushing) indicates the fulness of the capillary blood-vessels in the skin, due to the action of nerves which are controlled by the feelings of the mind (shame, modesty, timidity). Fear, like cold, produces paleness. Anger and grief sometimes cause a flush, sometimes pallor.

BREATHING.

Breathing is a remarkable muscular action. To an untaught person the breath seems to flow in and out in a mysterious way, of its own accord. It is so plainly necessary to life — and stopping it will so quickly put an end to life — that the Romans used the word "breath" (*anima*) for "soul"; while the word for "breathing" (*spiritus*) also signifies "spirit." The Greeks did the same with their words (*psyche* and *pneuma*).

The word "inspiration" means breathing in, or "taking breath"; "expiration" is breathing out; "respiration" includes both, and denotes breathing in general.

It is very important to understand the mechanism of breathing, as we may thereby be enabled to save life.

The chest may be considered as a pair of bellows, which sucks the air in when it is opened. It differs from the bellows in having but one hole (windpipe) for both the in-coming and the out-going air.

The frame, or basket, called the *chest*, is formed of movable parts. Each rib is hinged to the spine, and can move a little, upward and outward, when certain muscles pull upon it; this movement makes the cavity of the chest wider, and corresponds to the opening of the bellows. We do not move the

chest muscles in breathing out: the ribs sink of themselves, from their own weight and elasticity. So the bellows falls by its own weight, forcing out the air from the nozzle.

Some of the following experiments may here be useful:—

1. At a convenient time, remove all belts and other things that confine the body. Let the arms hang by the sides. Tie a piece of twine closely around the body, next the skin, about six or seven inches below the collar-bone. Then draw a full breath, and feel how the twine cuts, showing that the chest enlarges when we breathe in.

2. Again, using a tape-measure, note the circumference of the chest when at rest, when quite full of air, and when emptied as much as possible. (Assistance may be required.) The arms are not raised.

3. Measure the expanded chest with the arms raised, and notice that it is still larger than before. This is due to the action of some muscles at the shoulder, which, when the arm is raised, draw strongly upon the sides of the chest in such a way as to open or expand it.

4. One person should stand with his arms hanging by his sides. A taller person behind him grasps his arms and quickly raises them sideways, so that the hands meet above the head. It will be noticed that the air is sucked in at the mouth while this movement is being made. By raising the arms above the head, we can make air enter the chest of a person who has been suffocated, and has ceased to breathe. By keeping up the process for a long time, the blood becomes slowly purified, the heart is induced to beat, first feebly and then more strongly, until the breath comes spontaneously. This constitutes "artificial respiration," described in an appendix.

Abdominal Respiration. — The partition which separates the chest from the abdo′men is called the *diaphragm*. It is not flat, but rounds upward, as seen in Fig. 40. It consists chiefly of muscle, with firm white tendons at the borders. Like other muscles, it has the power of shortening. Being of a curved form, it becomes straighter when it shortens, the effect of

which is to enlarge the lower part of the chest. Or in other words, by its downward pull it causes a sort of suction. This draws in air by the windpipe, and produces breathing. *Diaphragmat'ic* breathing is the name given to this action. Another name given to it is *abdominal* breathing, owing to the fact that the region of the stomach and bowels is pushed downwards and forwards during inspiration. It is more distinctly seen in men than in women, while chest breathing is more distinct

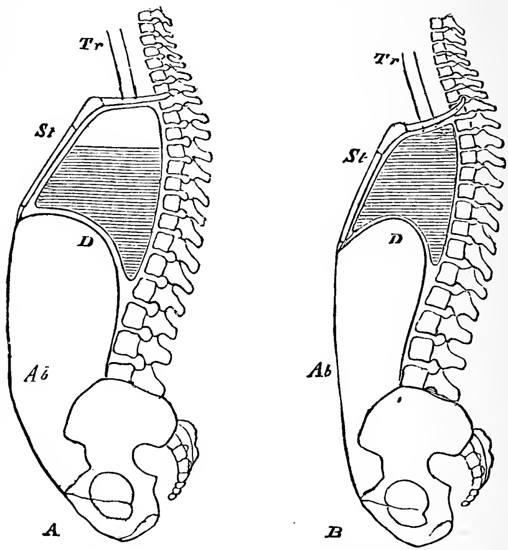


FIG. 40. — Diagrammatic sections of the body in *A*, inspiration; *B*, expiration. *Tr.* trachea; *St.* sternum; *D.* diaphragm; *Ab*, abdominal walls. The shading roughly indicates the stationary air.

in women. In this form of breathing, expiration is aided by the muscles of the abdomen, as may easily be felt with the hand. Fig. 40 represents both forms combined.

We seldom breathe as fully as we can. Suppose that the amount of air in the lungs of an average-sized adult, while sitting quietly, equals about 200 cubic inches. In drawing an ordinary breath, he takes in about 30 cubic inches more;

but by a strong effort he can inhale four times as much air, or say 130 cubic inches, making the lungs to contain 330 cubic inches. And by a reverse effort he can force out so much air as to lower the quantity to 100 cubic inches.

There are instruments called spirometers, for measuring the amount of air that can be forced out in breathing after taking a very full breath. This amount, on an average, may be seen from the above figures to be about 230 cubic inches; it is commonly termed the "vital capacity."

The "shallow" breathing is all that we require when sitting still. When exercising, the work done by the muscles at once throws into the blood an increased amount of waste material and carbonic acid, which comes to the lungs, and makes us feel that we need to get rid of it by full breathing. A weak person's lungs and chest soon grow tired in exercising, and he becomes uncomfortable, feeling the need of breath, but unable to take it. The chest and diaphragm must, therefore, be trained by exercise to be able to do hard and rapid work in breathing. Soldiers, runners, oarsmen, and many others greatly need this training. But it is good for all persons.

The pulse becomes faster when the breathing does; their duties are parts of one great work, and they assist one another.

A man sitting at rest breathes about sixteen times in and out every minute. His pulse is rather less than seventy in a minute. In women and children these numbers are larger. Exercise increases them very much. They are lessened by lying down, increased by standing. They may also differ considerably in healthy persons of the same age and sex.

A sigh is a full breath not caused by exercise. Panting is a series of hasty breaths. Sobbing is a spasmodic jerking-in of the breath. Hiccup is like sobbing, with a catch in the throat added. Coughing is a violent throwing out of breath, with a catch or partial closing of the throat, so as to make a barking sound. Sneezing is a violent throwing out of breath without the catch.

HYGIENE.

Temperature. — When the blood circulates rapidly and the heart and pulse beat strongly, a person is usually in good health. Such a one is less apt to take cold than a person in whom the circulation is sluggish; he is less easily chilled in bathing, and is less liable to have cold hands and feet.

"Keep the head cool and the feet warm" is one of the wisest medical proverbs. To prevent over-heating the head, let the room you study in not be warmer than about 65°;[1] a healthy child from ten to fourteen years of age seldom requires greater heat. Do not study with the head near a hot lamp or over a register.

To keep the feet warm take plenty of exercise every day, and do not sit still (at the age of twelve) more than an hour at a time; the air near the floor should not be below 60°; the feet must never be kept in wet shoes and stockings. Persons who live in too hot rooms are apt to have frequent colds.

There is a great difference in people as regards the heat they require. Europeans generally prefer the thermometer at about 60°; the inhabitants of the United States and Canada, near 70°. Some require thicker clothes than others. Little infants and very old persons must be kept thoroughly warm, for they may easily be killed by the cold.

In summer, a *dry* heat of from 100° to 120°, which is experienced in Arizona, is said to be more easily borne than a *moist* heat of 90°, such as we often have during "dog days."

Running is one of the best exercises for improving the circulation and power of breathing. It is natural to little children, and might well be practised by those who do not consider themselves little. In the beginning one should take very short runs, at moderate speed, and gradually increase both length and speed. All exercise that is useful to health ought to quicken the pulse and breathing considerably; run-

[1] Some authorities say 70°.

ning does this more than most other kinds of exercise, and there are few young persons who cannot bear the strain.

Clothing. — A bandage around a limb checks the circulation, making the blood stagnate. By winding a string tightly around a finger, we can squeeze out most of the blood and prevent fresh, warm blood from entering, which makes the finger cold. Tight garters prevent the free return of the blood from the leg and foot; and thus tend to cause disease of the veins. In fact, tight clothes at any point interfere with circulation and thus cut off "the blood, which is the life," from a part of the system.

The practice of dressing tightly in order to show the form of the body and make it look more slender is common and generally injurious. It prevails among the vain of both sexes. Tight clothes interfere with several of the greatest and most important of the functions of the body. They prevent a full breath being taken, and thus continually starve the blood by limiting the amount of oxygen that enters the lungs. They make it difficult to use the muscles vigorously, and so check exercise. They press on the stomach, liver, and intestines, interfering with their movements, and so hindering digestion and producing constipation. And finally, they check the circulation in the limbs, as has already been stated. The whole effect of tight dressing is injurious.

A person when clothed ought to be able to lift the arms straight up so as to touch the hands above the head. He ought to be able to draw a full breath without a feeling of tightness around the chest or abdomen. The use of tight belts is bad. Tight collars or neckties make the head and face full of blood, especially when we stoop in study; they are injurious to the eyes and may cause nosebleed.

There is one exception to the rule about tight clothing. When there is a tendency to diarrhœa, it is very useful to wear a flannel belt about the abdomen, rather tightly applied.

Asphyxia or **Suffocation** can be produced by sudden stoppage of breath (as in drowning or strangling), or by some poisonous

gases. In asphyxia the blood contains much carbonic acid, and little or no oxygen. The first and most important thing to do for its relief is to bring back the breathing. If a person has only just stopped breathing, a slap on the face with the hand or a wet cloth, may start respiration. If asphyxia has lasted for some time, there should be not a moment's delay in establishing *artificial respiration*, according to methods given later.

Fresh Air. — Our bodies are kept warm by the combustion of the food we take. The more food is burned, the more air is taken into the lungs. It is very desirable that the air should be pure at all times. When exercising, we draw in much more air — and it ought to be as fresh as possible. When sitting at rest, especially when studying, we need the purest and best air to enable us to think well. In close, crowded rooms people cannot study nearly as well as in well-aired ones; they become sleepy and tired; the head grows hot, and aches.

Air just breathed out of the lungs is very impure from the carbonic acid and other harmful gases which it contains. The perspiration from the skin increases the impurity of the air of rooms. In close rooms the air remains bad until it is taken out by the windows, doors, or ventilators. *Ventilation* means removing the bad air. It takes but a few minutes [1] for the air in an ordinary unventilated schoolroom to become bad, and to keep it good we need to change the whole of it several times every hour. Schoolrooms are very rarely so constructed that they can be ventilated well.

It is often necessary to open windows. There is danger in doing this that a draught of cold air may strike on some person, producing colds, face-ache, ear-ache, or worse complaints.

Bleeding. — When bleeding is profuse, it can almost always be stopped by firm pressure upon the bleeding spot with the thumbs or a hard roll of cloth. If necessary, keep up the pressure until a surgeon comes.

Moderate bleeding often stops of itself by the formation of

[1] Perhaps on an average we may say ten minutes.

a clot in the wound, which is nature's way, and is often better than washing with water.

Bleeding by jerks or spurts comes from an artery. To stop it, press on the artery just *above* the cut (between it and the heart) until a surgeon comes.

Bleeding in a steady stream is from a vein, and may be stopped by a pad of cloth tied upon the spot.

In nosebleed, sit with the head slightly bent over the basin; loosen the neck clothing; put something cold on the neck or spine; do not blow the nose.

Fainting is a sudden weakening of the action of the heart; the person may feel sick and dizzy, the action of the brain ceases, and consciousness is lost. When a person faints, he may fall to the ground; he usually attracts notice, and people are led by curiosity to crowd around him, which is the worst thing they can do; for it keeps him from getting what he most needs,—the fresh air. Lay the person flat on his back. Make the clothing around the neck perfectly loose. Do the same with the chest and abdomen. Open the windows. Fan the face or sprinkle it with cold water to excite breathing. Put smelling-salts to the nose to stimulate the lungs and heart.

STIMULANTS AND NARCOTICS.

One of the first effects of alcoholic drinks is seen in the skin, which becomes flushed, owing to an increased amount of blood in its capillaries. This is the effect of a nervous action, a sort of weakening. In people who use these drinks often the capillaries (of the nose and cheeks) remain enlarged, making those parts permanently red — a sign of injured circulation. Something of that sort goes on inside of the body; for instance in the kidneys, which are often injured by drink.

The alcoholic drinks at first increase the frequency of the pulse and breathing. They "stimulate" or spur on the heart and lungs to work more rapidly. Hence, they have a place in Medicine. But they belong to the class of remedies which are

capable of destroying life, and when a fatal dose has been taken, one of its effects is seen in the pulse and breathing, which grow slower and finally cease.

Alcoholic drinks lower the temperature of the body. This is exactly the opposite of what we should suppose when we see how flushed the face looks after drinking. It is nevertheless true, and can easily be proved by the test of the thermometer when large quantities are taken. It is also apparent in persons who are "dead drunk." If a person is going to be exposed to severe cold, which may possibly endanger his life, the danger is very much increased by drinking spirits.

Exhaustion from extreme fatigue, exposure to heat or cold, or hunger or bleeding, produce faintness, which is due in part to weakness of the heart. A generally safe remedy for such a state is a little ammonia (hartshorn). Wine and spirits are often used to restore people who are "far gone," that is, too weak even to eat; but it must be remembered that such cases are exceptions. For less severe fatigue (as when one has walked twice as far as one is accustomed to do) a safe restorative is found in tea or coffee or cocoa.

Persons who require to use all their strength and to keep it up for a long time, as pedestrians or athletes, find that, on the whole, the effect of alcoholic drink is not good: it does not increase strength.

A drink of an alcoholic beverage is likely to make a person *feel* stronger for a while. The sensation is not a truth-telling one. If the strength (of the hand, for instance) be then measured, it will not be found to be greater.

The effect of tobacco, in inexperienced persons, is to produce a great feeling of weakness. The heart shares in this influence. The pulse becomes feeble, and the circulation in the skin is lessened. If a person becomes a regular user of tobacco, this effect is no longer noticed as a rule; but in many persons another and a most unpleasant effect comes to be noticed, namely, palpitation of the heart, — a disease which is not likely to cause death, but which causes much anxiety

of mind and gives great discomfort. Palpitation, in such cases, may be looked upon as proof that the system is in a bad condition, unable to carry on its work through weakness.

SYNOPSIS.

The blood, forming $\frac{1}{13}$ of the weight of the human body, is the universal distributor of nutrition, reaching almost all parts of the frame. It is composed of serum, fibrin, and corpuscles. The "clot" of blood contains the two latter elements. Blood contains the equivalent of all the materials found in the structures of the body. Chemically analyzed, it resembles milk and muscular tissue.

Tying a limb so as to check the flow of blood will in time cause it to perish. Death follows great loss of blood; transfusion sometimes saves life.

The waste products of the system are carried off by the blood to the excretory organs, — skin, lungs, kidneys, etc.

The color of the blood is due to the red corpuscles; their color again is due to the presence of compounds of iron, a remedy useful for persons whose blood is thin; *i.e.* who have too few red blood-corpuscles.

The white corpuscles are very few in number compared with the red; the latter are supposed to originate from the former.

The blood is contained in a system of tubes (blood-vessels) and the heart.

The blood-vessels include arteries, without valves and with pulsations; capillaries (extremely fine), without either; and veins, with valves and without pulsations. The general circulation starting at the heart (left side) passes through arteries, capillaries, veins, back to the heart (right side). The heart acts as a pump; its strokes give an impulse which travels along the arteries, and is called the pulse. The capillaries are the vessels which bring the blood directly to the tissues which need nourishment. They also furnish material for the glands to form secretions from, and they take up the waste matters of the body, as before said. After passing from the capillaries to the veins, the blood has become dark in color from loss of oxygen and increase of impurity; it is then called *venous blood.* (Experiment on valves in veins.)

Venous blood entering the right half of the heart is pumped from

that part to the lungs, where it becomes purified and oxygenated; thence it returns to the left half of the heart, which forces it to resume its general circulation once more. This intermediate passage is called the *pulmonary circulation.*

The hepatic circulation is the system which collects the blood from the capillaries of the stomach and intestines and compels it to pass through the liver. This portion of the blood is rich in nourishment derived from food; it undergoes certain changes in the liver before passing on to the great vein near the heart.

The lungs fill the chest to the right and left of the heart. The air enters through the trachea, which divides and subdivides into the bronchial tubes, which open into the vesicles. From these the oxygen of the air passes to the blood in the capillaries, where it is fixed by the red corpuscles and so carried all over the body. Oxygen causes changes in the tissues similar to those of burning; the materials burned are those supplied by the food, and the result of combustion is chiefly water and carbonic acid. The latter is taken up by the blood, giving to it the dark color of "venous" blood; carried to the lungs, the carbonic acid is there discharged and breathed out.

The body heat is near 99° F. At the skin it is usually much less. The skin regulates the heat in the body; when the heat is excessive, perspiration occurs and cools the skin rapidly.

Blushing is a sudden filling of the capillaries of the skin. Some emotions cause pallor; some, flushing.

The word "breath" in Latin and Greek was the same as "soul" or "spirit," since breath is necessary to life. Breathing is caused by the basket-shaped chest enlarging and sucking in air through the trachea, and afterwards diminishing and expelling the air. Muscles attached to the shoulders and neck and ribs draw the chest open; the diaphragm has a similar and important action; but in expiration no muscular act is needed, since the chest contracts by its own weight and elasticity. (Experiments.)

A man at rest breathes in and out about 30 cubic inches. By making efforts he can make the amount 230 cubic inches. It is important to develop the chest so as to take in a liberal amount of air. Exercise which develops the lungs and strengthens the muscles of respiration is of great importance.

The pulse sympathizes with the respiration. The rate is variable in different persons; in men the pulse is usually under 70 and the respiration under 17 per minute; in women and children more rapid.

The position of the body influences them. Exercise hastens them very much.

Sighing, sobbing, coughing, etc., are peculiar forms of breathing.

A vigorous circulation is a sign of good health, and keeps off a tendency to colds. Exercise promotes it; too hot rooms weaken the circulation. 65° is a good average temperature in winter. In summer moist heat is very hard to bear. Running is one of the best exercises for the circulation and respiration.

A tight bandage around a part arrests its circulation and interferes with its nutrition. The same is true of tight garters and tight clothing in general; another evil effect is seen in the checking of respiration. Belts, collars, neckties and the chest clothing often impede circulation and breathing. A wide flannel waist-belt is of use in preventing diarrhœa.

Asphyxia is produced by strangling or by poisonous gases. The blood is deprived of oxygen and ceases to support life. If life is only seemingly extinct, it may be restored by artificial respiration.

Fresh air becomes polluted by the presence and breath of numbers of people; it then contains less oxygen and is less invigorating, so that study becomes difficult. Ordinary schoolrooms are very seldom well ventilated. Each scholar should have 1800[1] cubic feet of *fresh* air supplied by ventilation every hour; frequently not one-tenth as much is supplied.

Bleeding can be stopped by pressure on the spot. If the blood comes in jerks, we may apply pressure firmly just *above* the cut.

Fainting is due to failure of the heart to act. The remedies are fresh air, recumbent posture, loosening the clothes of neck and chest, sprinkling the face.

Alcoholic drinks at first increase the frequency of the pulse and breathing. This medicinal effect can be made useful in cases of exhaustion. A flushing of the skin is common and may injure the complexion permanently. Excessive amounts may so paralyze both respiration and pulse as to cause death. A lowering of the temperature occurs. For athletes alcoholic drinks are unadvisable; they do not add to the strength.

Tobacco in beginners greatly weakens the pulse and breathing. It not infrequently causes a disease — palpitation of the heart — in those accustomed to it.

[1] This is a moderate estimate.

SUGGESTED QUESTIONS.

Amount of blood in body: its component parts; coagulation; components of clot; nutritious properties of blood; chemical resemblance to some other substances; waste-products; effect of removal of blood; transfusion.

Red corpuscles: shape, number, deficiency of; iron in. White corpuscles.

Structures which contain the blood: general appearance of blood-vessels. Heart: size; position; tissue composing it; mechanical function; pulsation felt. Aorta and arteries; pulse; wounds. Capillaries: pulsation; nutrition; secretion; digestion. Veins: waste material; color; pulsations; thickness of walls; direction of flow (experiment); valves (experiment).

Pulmonary circulation: its purpose; double structure of the heart; course of blood through lungs; valves of heart; auricles and ventricles.

Hepatic circulation: its purpose; blood from the digestive organs; portal vein; passage of blood from liver to heart and lungs.

Lungs: situation; structure; trachea; bronchial tubes; vesicles; capillaries.

Oxygen: proportion in air; its use to the body; entrance into the blood; function of red corpuscles; oxygenation; oxidation; combustion; slow oxidation; changes in the tissues of body; products of oxidation, how disposed of.

Temperature of body: the skin as a cooling agent; cold-blooded animals; blushing and turning pale.

Breathing: ancient views (definitions); mechanical function of chest; its structure (experiments to illustrate expansion); how to hasten inspiration or to make it more powerful. Diaphragm: description; shape; change of shape; effect of its action. Men compared with women. Abdominal breathing: shallow compared with full breathing; numerical data; spirometer; vital capacity; effect of exertion; training the chest; sympathy of the pulse; rate of pulse and respiration; certain peculiar forms of respiration.

Taking cold: temperature of room and of parts of body; various temperatures preferred; effect of moisture in the air; running.

Tight clothing: interference with breathing, exercise, digestion, and circulation; certain garments.

Asphyxia: chemical state of the blood; remedies.

Fresh air: when air ought to be very pure; two sources of impurity of air; ventilation, how much required; dangers of careless management.

Bleeding: arterial; venous; remedies.

Fainting: cause; remedies.

Effect of alcoholic drinks upon the skin; upon the pulse and breathing; fatal effects; upon temperature. Cases of exhaustion from fatigue, etc. Athletes. Deceptive sensation. Tobacco; action upon heart and circulation; disease produced.

NOTES FOR TEACHERS.

The lungs will be much better understood if they can be dissected out of an animal (sheep, cat, frog) in an uninjured state, and inflated or blown up with a pipe inserted into the windpipe. It is surprising how much they enlarge, — how much larger, in fact, they are than the chest cavity, when they are fully inflated. It will also be perfectly plain that they shrink together and become very much *smaller* than the chest cavity, when they are wholly empty.

One of the simplest exercises for developing the lungs, and one of the best, is the practice of full breathing. The following is a good method: —

Let the windows be open to a suitable extent. Stand erect, head up, back straight, facing the window. Do not open the mouth. The arms being at the sides, raise them sideways slowly, without bending, till the hands touch over the head. While raising the arms draw in the breath; take three seconds for this operation; take three more, keeping hands above head and holding the breath; then three more to lower the hands as slowly as they came up. Wait a few seconds and repeat. Some persons become dizzy when they begin this practice. They must begin gradually, not at first taking so much time as directed, and not repeating. When accustomed to the practice, children may repeat the act six times or more.

The chest and abdomen must be free, so that no pressure is felt from the clothes; the collar loose.

This practice of *full breathing*, if carried out daily, will help many persons to avoid colds of the chest and throat. It will also help to get rid of troublesome little coughs.

A few practical remarks on *Ventilation* may here be introduced. —

The teacher should always bear in mind that the evils arising from cold and draughts may exceed those caused by bad ventilation. The scholars will, however, generally bear a lowering of the upper window-sashes for an inch or two. If the lower sash is raised, there should be a board set in front of the opening so as to turn the current of air upward. — The draught of an ordinary coal stove contributes very little to the removal of the close air of a schoolroom. The draught of an open fireplace in active operation is more efficient, though far from adequate to the needs of a class of forty or more. The flues that are ordinarily put in for ventilation are usually absurdly small. — The arrangements for artificial ventilation being thus defective, a teacher often finds the responsibility of ventilation thrown upon him alone. If he is willing to exert himself a little in this direction, he can do nothing more practically useful than to cause the scholars to leave the room at recess, while airing goes on; and to this he can add occasional free opening of the windows while the class rise and engage in light gymnastics.

CHAPTER V.

FOOD, DRINK, AND DIGESTION.

CLASSES OF FOOD.

The foods used by mankind are either animal, vegetable, or mineral.

Animal food includes not only meat (in the common sense of the word), but also the flesh of birds, fishes, and even reptiles and insects. Eggs, milk, and cheese are animal food.

Vegetable food includes the grains, and articles made from grain, as bread, pudding, porridge; leaves of plants, as spinach, lettuce, cabbage, dandelion; roots and tubers, as potatoes, beets, turnips; the pith of the sago-palm; sugar, honey, and similar sweets; oil, procured from olives, peanuts, cotton-seed, and many other sources.

Mineral food includes two very important substances, — water and salt; besides others, almost equally important, which are not visible as distinct articles, but are combined with other foods, — as lime, potash, soda, phosphorus, iron, silica.

This classification is useful and convenient, but imperfect. It does not take account of the fact that each kind of food can be separated into two or more substances which differ greatly. Meat, for instance, is composed of fat and lean, which are entirely unlike. And, on the other hand, the fat of meat is very like some of the fats or oils that are found in vegetables.

Such foods as oatmeal or maize contain several substances, which the chemist separates and analyzes. One of these is, chemically speaking, like the lean of meat. There is also

much starch, which resembles that of the potato. Sugar and oil are also found.

If we now study, not the food as it comes to us, in a mass, but the separate substances which compose food, we find that they form four groups or classes, as follows: —

1. Protein compounds, or proteids.
2. Fatty substances, or fats and oils.
3. Carbo-hydrates, including starch and sugar.
4. Mineral substances.

Animal food is chiefly composed of classes 1 and 2. Vegetable food especially abounds in 3, but contains all classes.

In explaining the uses and value of the different classes of food, we will omit class 4 for the present.

Class 1 comprises several distinct substances, among the most important of which are *albu'min* (represented by the white of eggs), *ca'sein* (by curd of milk and cheese), and *my'osin* (the basis of lean meat). Vegetable albumin is contained in wheat and other grains, in the juice of most vegetables, and in nuts. Vegetable casein is found in peas, and beans, and nuts. *Gluten* is a nitrogenous material found in grain, and composes the sticky part of dough. Associated with these, yet not strictly in the "proteids," are the *gelat'inous substances*, found in bones and sinews, and including jelly and glue.

Class 2 comprises a great many kinds of fats and oils, some of which are formed in plants, others in the bodies of animals. The cream of milk, the yolk of eggs, the oil of nuts and olives, are familiar examples.

Class 3 includes many sorts of sugar, both vegetable and animal. Starch is hardly found in animal food, but abounds in vegetable food of almost all sorts.

The number of substances included in these three classes is large, but they are all formed by nature from a very few "simple" substances, or "elements," of which the chief are carbon, oxygen, hydrogen, nitrogen, sulphur, and phos'phorus.

Carbon is the best known of these elements. It can

be conveniently shown by holding any article of food to the fire until it is "toasted to a cinder." The heat drives off the other elements, leaving the black carbon behind.

Carbon, hydrogen, and oxygen are components of all foods of the first three classes; but while classes 2 and 3 are *entirely* composed of them, class 1 contains in addition a fourth element, nitrogen, besides a very small amount of sulphur and phosphorus. Substances belonging to class 1 are often called *nitrog'enous* substances, while those of classes 2 and 3 are called *non-nitrogenous.*

Class 1, therefore, contains all the principal food elements, while classes 2 and 3 do not contain all. If a person were compelled to choose between an absolutely pure nitrogenous article and a purely non-nitrogenous substance, for his sole food, he would theoretically do better to choose one of the former kind. Fortunately, however, we are not required to make such a choice. In point of fact, there are very few kinds of food which are composed of only one of these classes. Meat belongs chiefly to class 1 (the proteids), but contains much of fat (2), and even a little sugar (3). The grains contain much starch, besides sugar, fat, and some of the proteids. Milk contains a good proportion of each class. This explains how it is possible for a person to live in health on one article of food. Infants and young animals thrive best upon milk alone. Certain wild animals live entirely on the bodies of other animals, and there are cases where men have lived upon a meat diet exclusively, without the slightest injury to their health.

When food is carefully selected, so as to consist entirely of one class only, it is found that the system cannot be supported. Lean meat and uncooked bones will certainly support a dog in health; but they contain fat mixed with the other material. Gelatine, in particular, is unfit to support life by itself; and even combined with other food it is of inferior nutritive power.

PURPOSE AND USE OF FOOD.

Food is required for several distinct purposes: —

1. For building up the body and repairing its gradual waste.
2. For enabling the muscles to do work.
3. For producing heat.
4. For forming the secretions.
5. For supporting nervous action.

1. **Growth and Repair.** — Young and growing persons eat comparatively more than grown persons; they require more. In later life, food is not needed for growth, but at all ages we require it to make up for losses. Besides this, a constant change is going on in the tissues which are already grown; old particles passing away from the body, and new ones entering its structure.

Chemistry and anatomy inform us that our bodies are composed of the same substances that compose the bodies of the lower animals. We have muscles, bones, skin, etc.; animals have the same; and for the purpose of building up or repairing our own substance we need nothing which cannot be found in ordinary animal food.

But chemistry goes further, and informs us that every substance existing in our bodies can also be made from materials found in vegetable food. And to this we may add, as a matter of experience, that there are vast numbers of human beings who eat no animal food, or very little, and yet are healthy and vigorous.

Certain mineral substances, as lime and phosphorus, are especially required by the bones and teeth; while the brain and nerves require phosphorus and sulphur.

2, 3. **Work and Heat.** — A large part of our daily food is used for supplying material for working-force and for heat. The way in which food produces force and heat is mysterious; but we can say that the changes which it undergoes, in thus acting, are something resembling those which we see in coal burning in a steam engine. That food can burn is evident;

we need only put it in the fire to prove the fact. That it can burn in our bodies so slowly as not to cause a dangerous heat is not so easy to comprehend. Many readers may think the expression "chemical change" a better one, or a more intelligible. At all events, the food presented to the system is so used as to be chemically changed, or burned; and it is by such processes that the muscles are furnished with "fuel," as we may call it, for performing mechanical labor or work.

The importance of this function of food is very great. The voluntary muscles compose four-tenths of the weight of the body; and they have for their sole duty the performance of mechanical work. Besides this, a great deal of unseen labor is performed by the heart, in pumping the blood; and a great deal by the muscles of the stomach and intestines, in digesting the food.

The muscles, while acting, produce heat, as can be proved by careful measurements with the thermometer; both the muscles and the blood being found to rise in temperature during active exercise. This fact shows the very close relation between work and heat.

The body, however, produces a great deal of heat in other ways, and the presence of heat is absolutely necessary to life.

4. **Secretion.** — Food is evidently required in order to supply the material for forming the peculiar materials contained in saliva, the gastric juice, the bile, and other secretions (see under "Digestion").

5. **Nervous Action.** — The actions of the nervous system have not yet been described. They are all bodily actions, and require food for maintaining them. Hence it is certain that our thoughts, wishes, and feelings, our sensations of pleasure and pain, our sight, hearing, and other acts of sense, are all supported by, and dependent on, the food we eat.

COMPARISON OF FOODS.

The Effect of Different Kinds of Food. — It is well known that foods do not act alike upon the body. A horse, for in-

stance, when fed with oats, feels more spirit and goes more willingly. Dogs fed entirely on meat are made excitable and often fierce. A moderate amount of meat has a good effect in making a person active; too much may make one excitable or irritable, especially if little exercise is taken.

The explanation of this effect of oats upon a horse is the fact that a considerable amount of a certain nitrogenous substance (gluten) is found in oats, very much more than in hay. It is found in most grain, and abundantly in peas and beans.

The nitrogenous substances found in food are of various sorts, but all have a somewhat similar effect.

The special value of animal food lies in its power to excite or arouse the body to activity and vigor; this it does more potently than such vegetable foods as oatmeal. Meat has more power of this sort than milk. Yet we cannot say that animal food is absolutely required, though often extremely useful.

Several very able-bodied races of men can be named that consume but little meat with their food.

The Scotch peasantry live mostly on oatmeal (a stimulating, nitrogenous form of vegetable food) with milk. They are among the hardiest people in the world.

The Zulus of South Africa, who rank among the bravest of savage warriors, support their magnificent muscle with milk and cracked maize.

The Arabs, another military race, live on barley and camel's milk, rarely eating camel's flesh.

Milk is an admirable food, containing enough of purely nitrogenous matter, with much fat (*i.e.* cream) and some sugar. It is easily digested by most persons, though some are unable to take much of it.

There are some foods which consist wholly of nitrogenous materials, while others consist wholly of non-nitrogenous substances.

Of the former class are lean meat and cheese. Of the latter, arrowroot, tapioca, and sago (consisting wholly of starch), pure

oils or fats, and sugar. Pure starchy or sugary food by itself is not capable of sustaining life for a long time; dogs thus fed die of starvation in a few days. Yet these foods are consumed in immense quantities by the populations of the world, and are certainly of great use. The body, however, does not seem able to put them to practical use unless some nitrogenous food is added.

Hundreds of millions of people subsist mainly on rice, which is almost pure starch, the chief addition made being some butter or other fat. Rice, however, contains six per cent of proteids, one-half as much as wheat or maize. The potato contains a still smaller proportion.

Value of Different Foods. — The power of food, or its value in supporting life, depends on the chemical changes through which it passes in the system. These changes are exceedingly complicated, and it is not worth while to attempt to explain them in this book. There is, however, one chemical change with which all are familiar, — the change which occurs in burning. This process has been used by chemists to determine *how much* effect the different sorts of food produce. For this purpose they measure the amount of heat produced by burning a given weight of different kinds of food.

When this is done, it is found that a pound of fat gives out in burning twice the heat that a pound of sugar or rice does, and fully four times as much as a pound of lean beef. This fact is believed by many to prove that fatty foods stand far above all others in the power to furnish force for labor. "A pound of wheat flour contains as much energy, to be converted into the heat which a laboring man needs to keep his body warm, and muscular strength to do his work, as two pounds of lean beef free from bone; while a pound of very fat pork is equal to over four pounds, and a pound of butter to nearly five pounds, of the very lean beef." [1]

Beans and peas contain a large amount of nitrogenous matter conjoined with starch; hence they are able, better than

[1] Professor W. O. Atwater, "Century," June, 1887.

most other vegetable foods, to take the place of meat. The chief objection to them is that they are rather hard to digest, unless very well cooked. The combination of beans with fat pork — a popular New England dish — has been found by lumbermen to be one of the very best foods for supporting severe toil.

Fat, whether of animal or vegetable origin, contains only three elements (carbon, hydrogen, oxygen); and as all these are found in starchy food and in animal (nitrogenous) food, it would seem that fat might be formed out of either class and that a man might grow fat on a diet of pure starch, sugar, or beef. In point of fact, pigs fatten readily on grain. Barley contains a small amount of fat, but it has been found by trial that a pig has "laid on" nearly five times as much fat as existed in the barley meal he was fed with. In such cases, it appears that the system of the animal has the power of changing a part of the starch of his food into fat. Hence persons who are excessively fat are sometimes advised to eat very little or no starchy food (or sugar, which amounts to the same thing). By this plan they are excluded from bread, rice, arrowroot, tapioca, farina, hominy, potatoes, puddings, cakes, sugar, milk; in fact, most of the articles which make up the bulk of a meal.

As a general thing, children under ten years of age do not require much meat; milk is better for them, and is usually much liked. Above that age, more meat is desirable.

An excess of meat is often injurious to the constitution. This and excess in sweetmeats are among the chief faults in the diet of Americans.

Fish is commonly considered a "lighter" food than flesh-meat; that is, less stimulating. It sometimes agrees with the stomach better than meat; but there is a wide difference in fish, and some kinds are hard or oily, and therefore slow of digestion.

Food that is of itself very good does not always suit the system. Cheese, for example, though a very valuable article,

is in altogether too concentrated a form to be eaten in large quantity. Its use is to add flavor to a meal of bread or biscuit and at the same time to fill the place of meat. A similar place is taken, among the Spaniards and Italians, by the onion.

Most food contains matter which is not nourishing, indigestible material, such as the fibrous or woody parts of vegetables, the skins and seeds of berries, the branny part of meal. If we could get rid of all such things, our food might be made more delicate, but would not necessarily be more wholesome. In fact, the stomach seems to require something to fill it up to a certain degree, more than the mere nutriment would do. The regulation of the bowels seems in many persons to require it. For this reason pulpy fruits and green vegetables are wholesome, as well as coarse oatmeal, cracked wheat, and hasty pudding, which are not only bulky, but contain bran, a material which has a direct effect in increasing the action of the bowels.

Certain kinds of food are necessary as a preservative against sickness. The fare of sailors in former times consisted chiefly of salted meat and hard biscuit. This can be borne for a while, but there comes a time when persons on such diet lose strength and become covered with sores; they bleed much, and if not relieved, die of scurvy. In the last century ships and even large fleets used to suffer from scurvy on all long voyages, sometimes to such an extent as to lose most of their men. A remedy for this scourge was put in use by Captain Cook, who circumnavigated the globe in 1772–5. He provided his ships with abundance of vegetable food and lime juice, and obliged the sailors to use them. The result was that he lost only one man by sickness in the three years' voyage, and not one by scurvy. At present the practice is universal, and scurvy is almost unknown. When sailors are brought to hospital with scurvy, they are fed with cabbage, onion, potato, and other vegetables. Lime juice, lemon juice, and the leaves of sorrel and mustard are also very useful. The instinct which

teaches cats and dogs to eat grass and other vegetable matter is doubtless useful to their health.

Fresh meat is of itself a good remedy for scurvy. The brine used in putting up beef and pork for sailors' use draws out a large amount of the nutritious juices of the meat, and so robs it of a great deal of its value. Such meat has not the health-preserving qualities of fresh meat.

DRINK.

Many kinds of drink are used for quenching thirst or pleasing the palate, but all contain water as their chief ingredient. All our food contains water, and some kinds are little else. The "juice" of meat, white of eggs, cream, milk, custard, porridge, jelly, the pulp of fruits, are examples of watery foods.

We require much water in hot weather when working hard, but in cool weather it is possible to go without drink if we have considerable fruit and a plate of soup at dinner. It is not generally best, however, to do without drink.

Two-fifths of a person's weight consists of water. The amount present in the body does not vary greatly from time to time. By running in hot weather one may lose several pounds by sweating, but that is quickly made up by drink. If a person sets about it, he can "train himself down" to light weight by that sort of exercise and by drinking less than he wants. This is done by men preparing for racing and other athletic contests in which they desire to be as light as possible. Yet training does not (as one might suppose) dry up the body, but rather takes away fat; for abstinence from drink is one of the surest means of lessening excess of fat.

Thirst is the craving of the whole body for water. It is felt not only in the mouth, but all over the body; there is a feeling of weakness, fatigue, heat, and perhaps headache, which water relieves. Soldiers marching in the hot sun with gun and knapsack are liable to these sensations, which, if not relieved, may lead to sunstroke. To avoid such danger, it has been found

best in such cases to make the soldier's load as light as possible, to have the neck-clothing perfectly loose, to wear no tight belts, and to drink as much water as is needed, — not a great quantity at once (which may do harm, and at any rate is soon sweated away), but a little at short intervals, sipping it slowly. These are the measures taken to preserve the English troops in India from sunstroke. A wet handkerchief or a bunch of damp leaves carried in the hat is useful.

Thirst may be a sign of disordered stomach. It is increased by salt or salt food or "hot" (*i.e.* peppery) food.

Very cold water, taken in large quantities when we are very hot and tired in summer, may cause colic, inflammation of the bowels, or death.

Ice-water is the favorite American drink. Many swallow large quantities of water at about 32° F., and it is thought that this is one cause why dyspepsia is so frequent here. No other nation uses it as we do. It certainly disagrees with many persons, more especially at the season when the stomach and bowels are apt to be delicate and easily "upset"; that is, in summer. Some persons ought never to drink very cold water. Even hot water is found a suitable drink by some. For a person overheated and tired out a cup or two of weak tea is often far more refreshing than a quantity of cold water.

Drinking seems a necessity in hot weather; but there are not a few in whom simply drinking water brings on summer complaints. Such persons should take little fluid. The carbonic acid in effervescing drinks, such as fresh soda-water, stimulates the stomach and mouth, so that thirst is quenched with a small quantity of fluid.

Acid fruits, such as lemons, limes, currants, the rhubarb plant, cranberries and other berries, often quench thirst better than anything else. A little vinegar in water is relished for the same reason.

Workmen in excessively hot places, such as furnaces for smelting iron, and engine-rooms, require great amounts of drink. In such places, experience has shown that alcoholic

drinks are not desirable. There is a craving, however, for something rather more nourishing or "sustaining" than mere water; and the craving is gratified by a mixture of oatmeal and water, which in some places is taken raw, in others is cooked to form a thin gruel. Sugar and molasses are popular in drink, doubtless for a similar reason, — because they supply nutriment very quickly.

AMOUNT OF FOOD.

The amount of food needed by a person varies in many ways. A man requires a little more than a woman; growing persons eat a good deal; people recovering from fevers frequently want to eat the whole time. The nations of the Arctic regions eat very large rations, and white men in those countries do nearly the same, while the people of hot countries are mostly temperate in their food.

There is a common notion that it is far better to eat too little than too much. In America most people have an abundance, and often do eat too much; but in Europe there are millions of poor people who would be in better health if they could afford to eat better food and more of it. Meat is used in very small quantities, most country laborers eating it but once or twice a week. The English navvy (railroad laborer) uses much meat and does a great deal more work in a given time than the French laborer; but experiments have shown that a generous meat diet enables the latter to do nearly as well as the Englishman.

A small appetite is natural to some persons. It is wrong, however, to suppose that it indicates refinement or delicacy, or that it is ladylike to eat little. Girls need about as much as boys, and at the age of fourteen (an age when growth is very rapid) should consume as much as an average man. As a general rule the appetites of children and growing young folks are a correct measure of what their bodies require, provided they have sufficient play and sleep and do not pamper themselves with candy and luxurious food.

A poor appetite may become a habit. If a person cannot eat breakfast, the reason may be want of sleep, anxiety, heat of the weather, over-fatigue, a disturbed stomach from improper food, or sleeping so late that the stomach does not have time to wake up and ask for food. The appetite can be improved by a short walk before meals, not enough to cause fatigue. In many cases of feeble health the appetite may be always poor, and the person may have to force himself to eat.

The habit of eating between meals is generally injurious, as it takes away the healthy appetite for meals. Eating is one of the greatest of a child's pleasures, but the enjoyment is all the greater when it is reserved for certain regular times.

A short period of abstinence from food may sometimes be of great benefit to a person. Some always eat too much, and the system cannot get rid of it fast enough to keep in health; and sometimes our appetite is stronger than it needs to be, and we may get a warning, in the form of a headache, to give ourselves a rest.

HABITS OF EATING.

Times for Eating. — We are not all suited with the same plan. Some persons eat but one meal a day, even in civilized countries; and among the Guachos of South America, who are in the saddle all day, it is the custom to have but one meal, consisting entirely of meat, at the close of the day. In our country three meals is the common plan; in parts of Europe from four to six are equally common.

Breakfast in America is a solid meal, resembling a dinner, taken soon after rising. In France and Germany people take a cup of coffee and a piece of bread, which "stays the stomach" and makes them feel able to work till ten or twelve o'clock, when a regular meal called "breakfast" is taken, about three hours after the coffee.

The benefits of a breakfast are plainly seen in the custom followed in tropical countries, of never going out of doors in the morning before taking a cup of coffee. This is a very

great preventive of the fevers which prevail there. It seems to be a fact that we take a fever or a cold more easily when hungry or tired or weak; and it seems also true that in the morning the body, though rested in one way, is not fully strong until a *breakfast* of some sort is taken. Strength grows as the sun rises in the sky. We may *feel* fresh and ready for anything at four in the morning, but unless we are used to it we shall find that two hours' work at that early time will use up our strength for the day, unless we lay in a supply of nourishment at the start. Most people are strongest in the middle of the forenoon or before twelve. Many students try to work before breakfast, but it is not a safe practice; yet there are some who can do it without the least harm, for we are not all made just alike.

Dinner. — Twelve o'clock is a common hour for workmen, and a suitable one. For business reasons a later hour is preferred by many persons; and in the United States it has gradually grown later, until at present six is a very common hour in cities, with a lunch at twelve or one. A hearty meal taken shortly before bed-time is likely to be injurious to young children, preventing sound sleep and causing dreams. They should not eat the family six o'clock dinner, but should have a lighter repast of their own. The use by children of strong tea or coffee at night may be extremely mischievous.

For children under fifteen it is best not to let more than four hours pass, after breakfast, before taking lunch or dinner. A substantial dinner at noon is best. If there is breakfast at seven and dinner at one, there ought to be a lunch between. The morning is the time when we most need food, for two reasons: first, because the system has been obliged to do without food for twelve hours, at least, before breakfast; and second, because morning is the time when a person is expected to do the best and hardest work. Nothing should prevent scholars and teachers from having a solid and wholesome breakfast.[1]

[1] These statements are intended to apply to those who follow the American practice of taking three meals a day. The foreign plan provides four, five, or six meals, which, of course, are comparatively light.

It is a sign of bad health when there is no appetite for that meal. Eating candy before breakfast is one of the worst possible habits. Young people must have sweet things; but they should take them after a meal of plain food. The appetite of some children is injured by drinking tea or coffee.

Whatever the hours may be, we ought to be regular, and not eat between meals unless it is necessary. In fact, the chief part of what is eaten out of meals is candy or cake — eaten not because we are *hungry,* but because it tastes good. It is natural to like sugar; well-made plain cake (without much spice) is good for children at proper times; good candy (not *cheap,* not *colored,* not *strongly flavored*) is good at the right time, and that is, in the place of pudding at dinner. Sweets, eaten between meals, generally leave the mouth in a sour condition; some of the sugar remains sticking between the teeth, and ferments, turning to an acid which attacks and rots the teeth.

If sweets are eaten, let the tooth-brush with soap be used afterwards. This may seem needless, or "fussy," but in truth the mouth is often foul and unwholesome after such food, and needs cleaning more than at any time of the day. Fresh fruits often contain sharp acids, and hence the same use of a brush may be required after eating them.

Another excellent reason for not eating sweets between meals is that they spoil the appetite for solid food. A quarter of a pound of candy is not a good thing if it takes away the appetite for a quarter of a pound of beefsteak.

DIGESTION.

It is evident that the body of a person is not composed of the things he eats. If we examine the parts of the body with a microscope, we find no crystals of sugar, no grains of starch, none of the cells of asparagus or cabbage or apple, or any other parts of vegetables. As for animal food, although the muscles, bones, and other organs of our bodies do resemble those of animals which we eat, yet it is certain that no piece of any animal

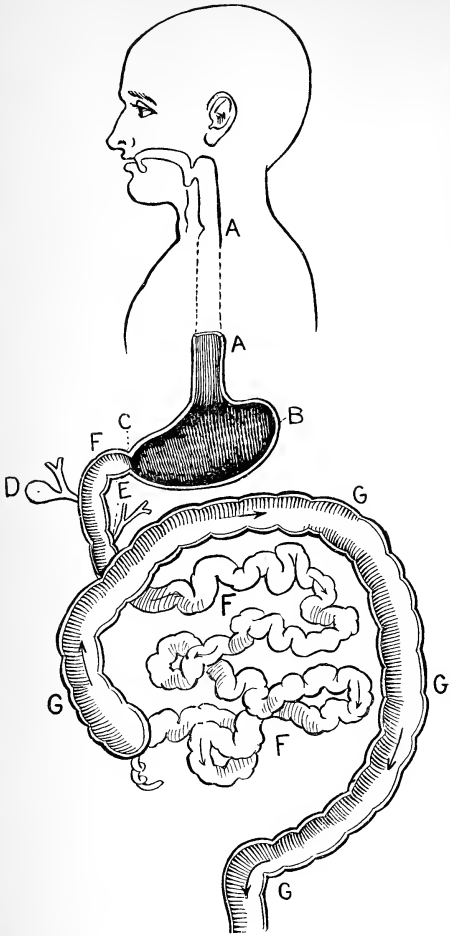


FIG. 41.—*A*, œsophagus; *B*, stomach; *C*, pylorus; *D*, gall-bladder; *E*, duct of pancreas; *F*, *F*, small intestine; *G*, *G*, large intestine.

food ever forms a piece of our bodies. Food has first to be changed to a fluid form, entirely unlike what it had previously.[1] The change occurs in the mouth, stomach, and bowels, and is called digestion. The processes of digestion are performed gradually, and occupy from half an hour to five or six hours. As fast as the food is made fluid by digestion, it passes through the walls of the stomach or intestines and enters the circulation of the blood, whereby it is carried to all parts, and supplied wherever needed.

Digestion can be subdivided into three parts, corresponding to the different regions,—the mouth, the stomach, and the intestines.

The work of the mouth is partly pre-

[1] Note, as an exception, the fact that fat and some sorts of sugar do not undergo chemical change in digestion.

paratory; it cuts, breaks, and crushes the food into fine particles, so that the digestive juices may work the better upon it. In addition, saliva is mixed with the food, which enables it to be swallowed more easily. Saliva oozes from certain glands; it is always flowing, but when a pleasant substance is tasted, or something good to eat is smelt, a larger quantity comes, making the mouth "water." When a person is very tired, or anxious, or excited, the mouth is apt to be dry, and eating is unpleasant. We cannot force the fluid to come by wishing for it, but we may assist nature to do so. Rest will help. If one is only thirsty, drinking relieves the difficulty, and in a minute's time the mouth becomes naturally moist. While the mouth is dry, it is not fit to take charge of food; only a very small quantity can be chewed at once; but by beginning little by little, the power of producing moisture comes by degrees. To swallow fluid continually by sips while eating is exactly the opposite plan, and discourages nature's efforts. (One of the larger glands is represented in Fig. 56.)

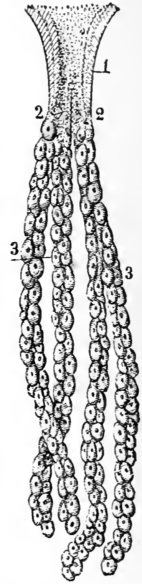


FIG. 42.—Gastric gland from stomach of rabbit, highly magnified. 1, tube through which the secretion passes into stomach; 2, tube dividing into branches; 3, cells of the divisions, full of gastric juice.

The office of the saliva is not merely to soften the food so that we can swallow; it is a true digestive fluid, and has the power of changing the starch in bread, potatoes, and other vegetable food to a sort of sugar. Starch by itself is not nourishing till changed to this sugar. Little infants cannot digest starchy food at all, and many die because forced to eat it mixed with milk.

The next part of digestion is performed in the stomach, which acts like the mouth in providing continually a quantity of fluid to mix with the food. This fluid, called gastric juice, is

poured out by multitudes of small tube-shaped glands, situated in the walls of the stomach (Fig. 42). It has the power of dissolving the proteids, including the fibres of animal food. Meat soaked in fat is protected by the fat from the gastric juice, and is therefore very slowly digested.

Different sorts of animal food require very different lengths of time to digest.

Food not digested in the stomach passes through a narrow passage, a very little at a time, to the intestines. The latter

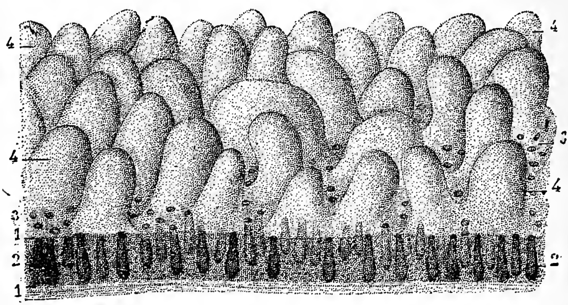


Fig. 43. — Tubular glands from the small intestine opening upon the mucous membrane, between the villi. Magnified 40 diameters. The hilly surface is the interior of the intestine, over which the food passes; the elevations (villi, 4, 4) are seen again in Fig. 44. 1–1, representing the intestine where cut through, showing a layer of muscles beneath, and the mouths of glands above; 2, glands; 3, mouths of glands.

form a very long tube, winding and turning many times, and the food passes slowly and steadily through it, becoming mixed as it passes with fluids coming from the liver, pancreas, and intestinal glands. Here fats are digested, or, rather, are mixed with a fluid which converts them into an emulsion;[1] and in this form they pass through the walls of the intestine and are taken into extremely fine tubes, called lac′teals, which join each other, and at last empty into the circulation of the blood.

The fluid which converts fat into an emulsion is discharged

[1] An emulsion is fat or oil mixed with some other fluid and broken up into such extremely small globules that it requires a microscope to see one. Salad-dressing is an example.

from the pancreas. The same fluid has a powerful action upon starch, by which it is converted into sugar, thus completing a change only partially effected in the mouth. Proteids are also digested by the pancreatic juice.

There are, therefore, three kinds of digestion, corresponding with three great classes of food: —

Mouth digestion, for starchy substances.

Stomach digestion, for proteids.

Intestinal digestion, for starch, proteids, and fat.

The fourth class of foods, or minerals, requires no digestion.

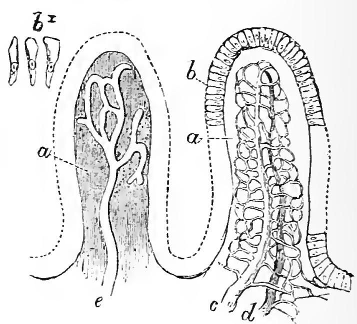


FIG. 44.— Two villi projecting into the small intestine, magnified about 50 diameters. *a*, substance of the villus; *b*, its coating of cells; b^2, detached cells; *c*, *d*, artery and vein, with connecting capillary network, enveloping and hiding *e*, the lacteal vessel which opens into other vessels at the base. (Diagrammatic.)

Water, and salt dissolved in water, simply pass through the walls of the mouth, stomach, or intestines, and go thus unchanged into the blood. When we are very thirsty, water is taken up with amazing rapidity by the stomach. Certain poisons enter the blood so rapidly that they produce death in a few seconds after being swallowed.

Pleasant tastes and flavors stimulate the system in such a way that it furnishes the required fluids more easily; they therefore aid digestion. But there may be too much of a good thing, as the boy found out who was told to eat all the maple sugar he could.

The sensations called "taste" are a mixture of the feelings of taste proper with those of touch, and smell. There are but few different kinds of taste, — sweet, bitter, sour, alkaline, salty. These are perceived by the tongue chiefly, and are just as distinct when the nose is shut. But the peculiar fla-

vors of the oils, rhubarb, spices, fruits, coffee, and many other things, are not noticed when the nose is held; they depend on some volatile principle (vapor or gas) which rises to the nostrils from the throat in the act of breathing. The feeling of softness or hardness of the food is enjoyed by different persons. The hot taste of pepper, the cooling taste of peppermint, are still other sorts of feelings.

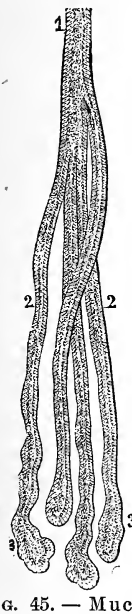


FIG. 45. — Mucous gland from intestine of dog.

Spices have another use, namely, as medicine for affections of the stomach and bowels. Natives of hot climates (as India), living almost entirely on vegetable food, are subject to certain ill effects,[1] to remedy which Cayenne pepper is much used. Good cooking will do still more to relieve the difficulty. In our climate we seldom require spices for this purpose; they should be regarded mainly as useful medicines.

Salt is not merely an article of luxury, but is necessary for the health of the body. It exists (dissolved), in considerable quantity, in the blood and many other fluids of the body. When people are entirely deprived of it, health suffers, and there is a strong craving for it. It improves the condition of cattle to give it to them.

Dyspepsia is a name given to a great variety of troubles. The word is Greek, and signifies *poor digestion*. Some of the common effects (or symptoms) among young people are headache, sick stomach, pain in stomach, constipation, bad breath, poor appetite for meals, with craving for food between meals, dull, heavy feelings of mind, ill-temper, and general weakness. It is common among little infants, owing to improper food, and occasionally causes their

[1] As flatulence.

death. It is not rare among children, often becoming an established habit which continues through life, causing great suffering and unhappiness.

The principal causes of dyspepsia have been given in a few words by Dr. William Pepper of Philadelphia: —

"In older children the mastication of the food becomes of great importance. If this is neglected, gastric disorder must sooner or later be induced. Irregularity of meals, undue variety of food, the premature use of tea, coffee, or spices, the unlimited use of ice-water, of fruit, or of sweets, the pernicious habit of eating candy, cake, or fruit between meals, — such errors are responsible for a vast amount of dyspepsia in childhood and for an infinity of ill-health subsequently."

We cannot tell what kinds of food are good for man until we have tried them. For example, grass and leaves are excellent food for cattle; but when tried, it is found that man has not the power to digest them. Cattle are furnished with a very large apparatus, consisting of several stomachs, which enables them to digest such foods. In addition, cattle have very large, broad, grinding teeth (molars), with which they are constantly chewing their food; they have also the power of raising that which is swallowed, from the first stomach to the mouth, for the purpose of "chewing the cud," and this gives their food a more thorough working over than we can give to ours.

A great deal of food can be eaten raw. Onions, turnips, carrots, tomatoes, nuts, apples, and other fruits are examples. Many persons prefer them raw, while others like them cooked, and still others are made ill by eating them raw. Some leafy articles, however, are always eaten raw, as celery, parsley, and lettuce; while others are always cooked, as asparagus.

Meat can be eaten raw without injury, unless it contains a good deal of connective tissue; in fact, the stomach digests it more readily when raw. And grain, the staff of life, can be eaten raw, though it is certainly less wholesome so.

It is not what we eat, but what we digest, that nourishes us.

And this may remind us that one person's stomach has no right to set up a rule for another person's, for we are not all alike; each of us possesses, it is true, a stomach, but one person's may be much more able than another's to do the work it is asked to do. A delicate stomach has to be "humored" by its possessor. It is a misfortune to grow up with that sort of stomach, for we need the strongest and best service from this servant of ours, to enable us to do good work with the whole of our body.

The time during which the stomach can be made healthy, vigorous, and hearty, is youth, — beginning with the first day of life and going on to adult age. The way to do it is for parents to give suitable food, in proper quantities, at the right times. A man or woman thus brought up does not have to keep thinking, "What makes my head ache? or my side ache? or why can't I do my work to-day?" It is not too much to say that one-half of the discomfort, pain, and actual disease of life comes from putting things into the stomach that have no business there.

COOKING.

Bad cookery does as much harm as bad food.

It has been said that "man is a cooking animal." No other creature possesses this art, and no other needs it as he does. If he had to depend on natural food, he would be nearly confined to the tropics. There is at present no race so low as not to understand the use of fire in preparing food.

Cooking is useful for several reasons: —

1. It draws out nourishing matter (gelatine, fat, etc.) from the bones used in making soup.

2. It destroys the life of certain minute parasitic creatures called trichinæ, which are found in the flesh of diseased pork (rarely in other meat), and which, if eaten, cause severe, often fatal disease. In several of our States there are laws which oblige those who slaughter swine to have the meat examined by an official inspector with the microscope. If the

creatures are found, the pork is condemned. If pork is cooked so as to be "very well done," the heat kills them, and the meat is eaten without their being perceived, for they are extremely small. Eating raw pork, or raw sausage made from pork, can hardly ever be safe, though a great many do it.

3. It makes food taste better, — or ought to. A good cook can make food attractive to the eye and pleasant to the taste; and a reasonable amount of sugar, spice, and the like condiments used for this purpose does good, for it is found by experience that the stomach works more willingly when we give it food in a pleasant way and put it in good humor. This is of very great importance for the sick and invalids, who often cannot eat at all unless things are just right, and whose life may depend on the food much more than on the medicine they take.

4. It gives warmth. Most people derive more benefit from a warm meal than from a cold one, except in hot weather. Many drink hot water or hot milk and water at meals instead of cold water; for some this is beneficial, for others not.

5. Many different kinds of food are mixed in cooking. This is useful when not carried too far. Nature does the same in many cases: the lean and fat of meat come mixed; sugar comes in most vegetables united with albumen and starch; flavoring substances give taste to the radish, the carrot, fruits, nuts, grains, — in short, to almost all natural food; and that excellent food, milk, is a natural mixture of sugar, albumen, casein (cheese), fat, and various salts. In cooking, therefore, it cannot be always wrong to mix these substances. But we learn by experience that certain mixtures may do harm, especially when "rich" or highly spiced. Such food makes one feel heavy and stupid, or causes a burning or heat at the stomach, or a sick headache. A bad breath often goes with these symptoms. Much of this trouble is caused by the excess of spice and sugar; much also by excess of fat, which, when overheated in cooking, is one of the worst things for the stomach. Butter is put into cake and pie-crust, and for the first

day it may be sweet, but afterwards is apt to turn rancid; but the cake is eaten all the same.

It is natural to mix certain kinds of food. Very stimulating articles, such as meat, are commonly eaten along with potato and other vegetables, which are not stimulating. Bread, and articles made from wheat, barley, oats, and other grains, contain all the necessary ingredients for good food, but their strengthening power is improved by a little meat or butter, as in sandwiches, or by adding milk, as for bread and milk. Oil is similarly added to lettuce.

6. The white of an egg (called albumen) turns hard when boiled. This process is called coagulation. For the easiest digestion, it is recommended that the egg be eaten either beaten up raw or else boiled full twenty minutes. The taste of the consumer, however, must be consulted.

Albumen is found in meat also, and is coagulated by boiling or roasting. If the fire is quick and hot, the outer layer of meat is at once made hard enough to protect the inside; that is, to keep the juices from oozing out. Meat so cooked (by boiling, roasting, or baking) will be juicy inside.

If we wish to get all the nourishment out of meat by boiling, to make a soup, we cook it very slowly, hardly keeping it at a boil.

7. Cooking softens the fibrous tissue of meat which abounds in the muscles; the effect is to make the fleshy part of the meat tender.

8. Flavors are produced in roasting meat which add to its attractiveness.

9. Cooking is necessary for all sorts of starchy food, whether made from grain or from potatoes, sago, etc. The hard grain may be made into soft flour; but if that flour is examined with a microscope, it is seen to consist largely of little grains or cells, which are solidly put together and defended by coats which are not easily penetrated by water. In this condition the starch can be digested, but slowly; and it is far preferable to soften it first. When flour is mixed with water and baked, or when

oatmeal or rice is boiled, the starch-cells absorb large quantities of the water, and swell up into a soft mass. Some kinds of food cook in a few minutes, but when the starch is in a condition which resists the process (as in Indian meal), it may be hours before it is wholesomely cooked. Thin cakes require very much less time than loaves, as the heat does not at once reach the interior of the latter.

10. Baking and toasting partially change the starch of the outside parts to a wholesome, digestible article called malt sugar. The crust of bread and the brown of toast contain it.

11. Light bread is more wholesome than heavy bread. The lightness is procured by chemical means — as by mixing saleratus and cream-tartar; better, by yeast; better still, by long kneading. The object is to get the bread full of little bubbles of air, or of some harmless gas, so that when baked it may be spongy, and easily mix with the fluids of the mouth. Bread or cake that is slack-baked, soggy, or doughy, is unwholesome, for it forms lumps which do not let the digestive fluids enter and mix with them.

Even if well baked, bread is often improved by standing some hours, till some of the water has evaporated from it and it has lost some of its softness. It is then called "stale." In this state it is more wholesome. Bread that will not cut easily into slices is too soft.

Why is pie-crust complained of as unwholesome? For several reasons. It is hard to make it light and porous, as good bread should be; the bottom crust is usually soggy and underdone; fat or butter is mixed with the paste in a way which usually injures it; the butter itself may be injured by cooking, and it is seldom that a delicate palate fails to notice a slight rancidity in the crust, especially after it has been kept some time. Good paste (a rare article) is flaky; it melts in the mouth; that is, it is so thoroughly mixed before baking that it quickly crumbles and is at once reached by the fluids of the mouth.

12. The simple melting of fat does not make it unwhole-

some; but overheating, such as occurs in frying, is apt to make it disagree with the stomach. That which drips from roasting meat is mixed with browned flour to form "made gravy"; and this sort of gravy is unsuitable for many persons to eat.

13. Frying, when properly performed, improves the taste of fish and some other foods. It is very injurious when so performed as to allow the fat or butter to soak in. To avoid this, the fat must be boiling before the article is put in, or else very little fat must be used, and a hot griddle. After frying, the food may be placed on paper, to soak away the superfluous fat. Boiling fat is so much hotter than water, that frying is done in half the time that is required for ordinary boiling. Frying is, therefore, a very quick and handy process. But not one cook in ten has the skill, and is willing to take the trouble, to fry properly; hence many people object to all fried food.

SYNOPSIS.

Man's food is derived from the three kingdoms, — animal, vegetable, and mineral: the latter includes water.

Food, as we find it in nature, is almost always a mixture of different substances. If we classify these substances, we find them divisible into four groups, — proteids, fats, carbo-hydrates, and minerals.

Proteids comprise albumin, casein, myosin, gluten: the gelatinous substances are allied to them. These, and the fats, are abundant both in the animal and the vegetable kingdom. Sugar and starch are characteristic of vegetable life. These substances are very numerous, but are all formed from a very few elements. Carbon (coal), hydrogen, oxygen, are found in all foods of the first three classes; but class 1 contains nitrogen in addition, besides a very little sulphur and phosphorus.

It is very difficult to procure any food which consists of one of these classes exclusively. Meat, milk, and grain contain some of each class. An exclusive meat diet is sometimes used without harm. But diet consisting strictly of one class of food does not support the system. Gelatine is especially innutritious when exclusively used.

Food is required for building the body, for repairing, for muscular work, for heat, for the secretions, and for nervous action.

Young persons while growing require comparatively more than grown persons. The body can be entirely built up from materials found in the bodies of other animals; it can also be built from substances found in vegetables. Lime and phosphorus are required especially by the bones and teeth; sulphur and phosphorus by the brain and nerves.

Food is consumed or burned slowly in the system, so as to produce heat and mechanical force. The latter is developed by the action of muscles, both voluntary and involuntary. Muscular action develops heat. Heat is generated in other ways also.

Secretion and nervous action are supported by food.

The exciting or stimulating action of oats (for horses), or of meat, depends on the presence of nitrogenous material. Many foods, such as maize, oatmeal, and milk, are not classed as specially stimulating foods for man, yet are capable of sustaining great bodily vigor.

An exclusively nitrogenous or non-nitrogenous diet will not sustain the system. Yet many foods belonging exclusively to one class are very useful when combined with the other class.

In undergoing combustion, fat gives out much more heat than sugar or starch; and the latter much more than lean meat. To some extent this indicates the value of these foods as producers of force.

Leguminous plants contain much nitrogen, but their great food-value has the drawback of comparative indigestibility.

Fat in the body can be formed from starchy, sugary, or nitrogenous food. Starchy and sugary food may be excluded from the diet of obese persons.

Excess in eating meat and sweetmeats is common. Fish is lighter food than meat. Some food is too concentrated to be borne well by many stomachs. Mere bulk is useful in the case of certain indigestible parts of fruit, vegetables, and grain.

Scurvy is a poor state of the blood, caused by deficiency of vegetable food, and by substituting salted for fresh meat. It affects sailors and Arctic travellers; in the last century it used to be very fatal, but it is now understood to be preventible by correct diet.

Water is the chief element of drink, and an important one in food. It forms two-fifths of the weight of the body. Violent exercise removes much of it (in training). Abstinence from drink lessens fat. Thirst is felt throughout the body. Sunstroke may be prevented by

relieving thirst, loosening the clothes of the chest and neck, and carrying something wet in the hat.

Thirst may indicate disorder of the stomach, or may be unnaturally stimulated by food.

An excess of fluid in hot weather deranges the bowels; the effect is worse if the drink is cold (ice-water). Hot water, tea, effervescent drinks, acidulated drinks, and oatmeal gruel, have their special value for many persons as summer beverages. Acid fruits are useful in the same direction.

The amount of food required differs greatly in different conditions. Generous diet, with meat, improves the working power. Growing children require large supplies, and if their food is suitable, they had better eat as much as appetite calls for. Poor appetite may spring from disordered habits of living, neglect of exercise, improper food, or eating between meals. Occasionally the omission of a meal is found beneficial.

The number of meals taken daily varies from one to six, and persons can enjoy health under either plan. An early meal is generally required to give strength to begin the day's work, or to protect against the noxious effects of weather or climate; this meal may be light or full. Exertion before breakfast should generally be restricted. In simple life, dinner may well be taken at noon: a hearty meal just before bedtime is injurious to children. Children usually require lunch four hours after a meal.

Eating between meals usually disorders the stomach or takes away the regular appetite. If necessary, satisfy appetite with plain food, not cake or sweets. The teeth should be brushed after eating sweet things.

Our food mostly passes through chemical changes in digestion. No portion of an animal or plant, consumed as food, exists as such in any part of our bodies.

Digestion requires from one to six hours, and is accomplished by three processes, which take place in the mouth, stomach, and bowels.

In the mouth food is cut and ground fine, preparatory for the work of the stomach. Starchy food is partially digested in the mouth by the action of saliva. Continual swallowing of liquid during eating interferes with this process. Starch is feebly digested, or not at all, in infancy.

The stomach furnishes the gastric juice (from glands in its walls), which dissolves proteid substances. The time required varies much.

In the intestines food is mixed with various fluids, of which that

coming from the pancreas is known as especially a strong digestive. Here starch and proteids are further digested, and fats are converted into an emulsion.

The products of digestion are fluids and emulsions. The former pass into the blood-vessels, which convey them first to the liver, then to the heart. The latter enter the lacteals and are carried to the heart.

Tastes and flavors have their use in stimulating digestion. There are few tastes; flavors are perceived by the sense of smell. Spices and flavors have medicinal virtues, and should not be used too much in food. Salt is a necessity of life.

Dyspepsia (poor digestion) causes many troubles in young people, and even in infants. The chief causes have been mentioned. Raw food is digested by animals more easily than by man; their stomachs are in many cases formed quite differently, and their teeth enable them to dispose of food which we can hardly swallow. Many vegetables can be eaten raw; tender meat is more digestible raw.

People differ greatly in their powers of digestion. No food nourishes unless digested. Youth is the time to lay the foundation of good digestion.

Cooking is practised by all men. It has many objects: —

1. Extracting nutriment from bones.
2. Destroying parasites (trichinæ in pork).
3. Improving taste, which aids digestion.
4. Giving warmth.
5. Mixing and combining food. Nature gives us the hint for this in many ways. In cooking we often err in our mixtures, especially by using an excess of spice, sugar, or fat. Nitrogenous and non-nitrogenous articles are often properly combined.
6. Coagulating albumin, as in eggs and the outer part of meat.
7. Softening the fibrous tissue of meat.
8. Developing flavors.
9. Swelling and softening the grains of starch in flour, meal, potatoes, etc.
10. Changing flour to malt sugar.
11. Subdividing the mass of bread by making it "light." It is thus easier to digest. Stale bread is wholesome. Pie-crust is unwholesome when heavy or stale.
12. Fat overheated becomes unwholesome.
13. Food soaked with grease in frying is very slow to digest. Quick frying in very hot fat is recommended.

SUGGESTED QUESTIONS.

Various sorts of food: animal, vegetable, mineral. Why this classification is imperfect. Chemical classes of food. Proteids: some subdivisions and examples. Albumin, casein, myosin, gluten. Gelatinous substances. Fatty substances: examples. Carbo-hydrates. Elements: carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus. Nitrogenous and non-nitrogenous food. Composition of meat, grain, milk. Values of certain diets. Exclusive diets.

Uses of food: growth; change; origin of materials; vegetable and animal materials for support; mineral substances. Work and heat: steam-engine; combustion of food; fuel of muscles; amount of muscular work; muscular heat; other sources of heat. Secretion. Nervous action.

Effects of meat, oats, hay, grain, peas, and beans. Nitrogenous food: effect: activity. Foods of certain races: Scotch, Zulus, Arabs. Milk. Exclusive diet; combinations. Rice, potatoes. Values of foods compared; combustion giving rise to heat; compare fat, beef, and sugar or rice. Beans.

Possible origin of fat in the system from certain classes of food: starch, sugar, beef, grain, farinaceous food, etc.

Meat at different ages. Excess in certain articles. Fish. Concentrated foods. Innutritious material in food: vegetables, fruit, coarse grains. Sailors' fare. Scurvy: preventives. Captain Cook. Salt: effect upon meat.

Drink: chief ingredient. Watery foods. Amount of water in body: diminution; exercise; fat. Definition of thirst. Sensations. Dangers and precautions. How to drink. Sunstroke. Causes. Temperature of water drank. Certain refreshing drinks. Carbonic acid. Vegetable acids. Furnace men. Oatmeal. Sugar.

Amount of food required. Large eaters. Poverty. Meat for laborers. Needs of growing young people. Their appetites. Eating between meals. Abstinence. Excess.

Number of meals daily. Breakfast in different countries. Value of an early meal. Work before breakfast. Dinner time. Length of interval between meals. Late meals. Appetite for breakfast. Tea and coffee. Regularity of meals. Sweets. The teeth.

The building of the body from foods. Changes undergone by food. Digestion. Time required. Kinds of digestion. Mouth digestion.

Saliva: its office. Teeth. Dry mouth in eating. Drink taken while eating. Sipping. Starch digestion. Infantile digestion.

Stomach digestion. Gastric juice. Fat.

Intestinal digestion. Fluids of intestine. Fats. Pancreas. Emulsion. Lacteals. Starch and proteids.

Absorption of water, salt, poisons, etc. Tastes and flavors: their use. Sense of taste; of smell; flavors how perceived. Kinds of tastes. Other uses for flavors (spices). Chief use of spices. Value of salt.

Dyspepsia: meaning, symptoms, causes. In early life. Digestive powers of animals. Cattle. Raw food: vegetable, animal. The stomach: individual differences, delicacy, heartiness; how to educate it; value of such education.

Cooking: who employ it. Gelatine. Bones. Soup. Parasites. Pork. Slaughtering. State laws. Heat in cooking. Raw sausages. Pleasant tastes. Condiments. Invalids. Food *versus* medicine. Cold meals. Hot drinks. Mixture of foods: natural; artificial; when harmful. What foods are to be mixed. Coagulation. Eggs. Cooking meat: two methods. Softening fibres. Flavors from roasting. Grains of starch: slow or rapid cooking required. Malt sugar. Light and heavy bread. Stale bread. Pie-crust. Fat when cooked or melted. Gravy. Frying: good and bad way.

NOTE.—The reader will find no mention of "acoholic drinks" in connection with the chapter on Food. For an expression of opinion by various medical authorities upon the use of these drinks as a part of diet, reference is made to Appendix I. The subject is discussed at length in Chapter XII.

CHAPTER VI.

THE SKIN, CLOTHING, AND BATHING.

THE skin consists of two layers, the *epider'mis, cuticle* or *scarf-skin*, and the *der'ma* or *true skin*, beneath the cuticle.

If we thrust a needle into the skin, a drop of blood appears at once; but if we graze the knuckles so as to scrape the surface, it may be some time before any blood comes, and sometimes none appears. In the latter case only the outer thin layer (cuticle) is injured, while the needle, piercing the cuticle, enters the true skin beneath, where there is such an abundance of delicate blood-vessels that some of them are always opened by the point. (See Fig. 51.)

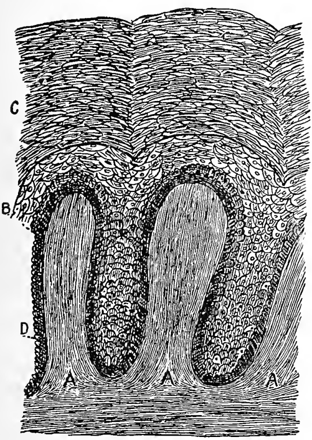


FIG. 46.—Skin of the negro, in section, magnified 250 diameters. *A*, true skin; *B*, *C*, *D*, epidermis; *C*, horny layer; *B*, *D*, deeper layer of epidermis; *D*, layer of pigment-cells. The projections, like fingers, at *A A A* are "papillæ"; the epidermis fits in between them.

The microscope shows that the cuticle is made up of little bodies called cells: those on the outside are flat, those lying deeper are rounded. New cells are constantly forming at the lowest part, where the cuticle rests on the true skin: this increases the thickness of the cuticle, but, on the other hand, a constant loss or wearing away occurs on the outer surface, commonly in particles too

small to be noticed. Washing removes an outer layer of cells. When the body is soaked in warm water, — and still more, when it sweats freely, — these surface-layers are softened, and are easily rubbed off in the form of little white, soft rolls.

The outer layer of cuticle is called the horny stratum or layer; manual labor makes it thick and hard on the palms of the hands, and going barefoot has the same effect on the soles of the feet. (Figs. 46, 47, *C*.)

The deeper layer of the epidermis (Figs. 46, 47, *B*, *D*) possesses a layer of cells (*D*) which contain coloring-matter. It is this which gives to different races and different individuals their varying hues and complexions, — light, dusky, tawny, coppery, yellowish, brown, black. Exposure to the sun increases the pigment in a light skin, which gives rise to "tanning."

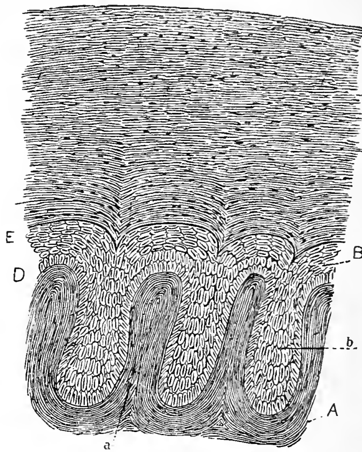


Fig. 47. — Section through part of the nail and its bed, highly magnified. *A*, corium, raised in ridges, *a*, fitting in between ridges, *b*, of the nail; *B*, *D*, deep layer of cuticle; *C*, horny layer. The letters correspond to those in Fig. 46.

A blister is formed by the whole thickness of the epidermis becoming separated from the derma, and raised above it by a watery fluid. Vaccination produces a kind of blister, properly termed the *vaccine vesicle;* some diseases produce small blisters. Sunburn may cause blisters, or may only make a thin layer peel off the surface of the cuticle: a similar thin layer comes off after an attack of scarlet fever.

The *nails* are composed of cells belonging to the epidermis put together more compactly than elsewhere. The analogy may be seen by comparing Figs. 46 and 47. In the next figure

(48) it is shown that the nail is continuous with the epidermis of the finger. The root of a nail is the soft part, running in for a short distance where the skin is folded inward. The end of the root, where it starts to grow, is in contact with true skin, and the whole bed of the nail rests on true skin, so that, as the nail moves forward over its bed, it grows at all points at once, and its thickness increases as it approaches the tip of the finger.

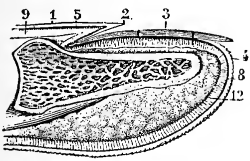


Fig. 48.—Section of nail and parts beneath. 1, 2, 4, horny layer of cuticle, continuous with 3, the nail; 5, 8, deep layer of cuticle; 9, 12, derma.

The *hair* is an appendage to the skin, analogous to the nails; like them, it is composed of compact, hardened cells, and grows from a portion of true skin. The little pit in which a hair stands is called a *hair-follicle;* the hair grows from the bottom of the pit, where it is connected with the derma. Each follicle has one or more small *seba'ceous glands* opening into it, from which an oily secretion is discharged upon the hair. That which is not retained on the hair spreads over the surface of the skin. In some parts of the body (as the nose) the hairs are very small, and the oil-glands very large in comparison; hence the oily appearance of those parts.

Sweat-glands consist of coiled tubes ending in straight tubes, which discharge on the surface of the skin; the openings of the tubes are called *pores.*

Fig. 49.—Section of skin from the palm of the hand, natural size. 1–1, epidermis; 2–2, papillæ; 3–3, derma; 4–4, subcutaneous cellular tissue and sweat-glands.

When a hair or a nail is pulled out, the true skin at once begins to restore it; it grows again. The same happens when a piece of cuticle is destroyed. But if the true skin is destroyed or injured, the power of reproducing the skin, hair, and nails is gone. After recovery from a deep burn, for instance, the scar is not composed of true skin, with epidermis, but of a whitish material, which is strong, but is not a very perfect substitute

for skin, and has besides the very great disadvantage of gradually shrinking, so that the parts are sometimes pulled out of shape. After a light burn the skin may repair itself completely in a few days. Such an injury does not prevent the growth of new hair. A lost finger-nail may be replaced by another, quite as good as the first, if the bed of the nail is not injured.

The *true skin,* or cutis, is much thicker than the cuticle. It is sometimes called the *corium,* from the Latin word meaning "hide." From it grow the epidermis, the nails, and the hair. In it, as we have seen, are found hair follicles, sebaceous or oil glands, and sweat-glands; to which we will now add *nerves* and *blood-vessels.*

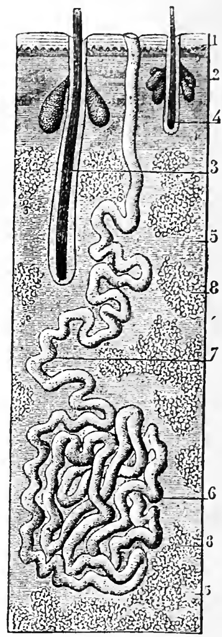


FIG. 50.—Skin, in section, enlarged 20 diameters. 1, epidermis; 2, derma; 3, hair follicle, with sebaceous glands; 4, rudimentary hair-follicle; 5, subcutaneous tissue; 6, sweat-gland; 7, its duct of discharge; 8, fat-cells.

As seen in Fig. 51, the true skin contains an abundance of small arteries and veins, from which loops of capillaries arise, which occupy the papillæ or projections shown in Figs. 46 and 47. There is an abundant supply of nerves also, of which more will be said. The blood in the true skin shows readily through the cuticle of the light-skinned races. The thickness of the cuticle, however, differs in individuals.

The true skin is chiefly composed of a tissue of strong fibres, matted or felted together so as to form a firm yet pliable and elastic covering for the body. In animals these fibres are hardened, by the process of tanning, which converts the true skin to leather.

FUNCTIONS OF THE SKIN.

The skin has many functions and uses. Among the most important are those of: 1. Protection; 2. Sensation; 3. Perspiration; 4. Regulation of the bodily temperature.

1. **Protection.** — Our bodies are constantly touching things. If our nerves were not covered over, every touch would give pain, and life would be unendurable. If the little blood-vessels were not covered (by a cuticle), the slightest rub against the body would set them bleeding. Besides this, the parts under

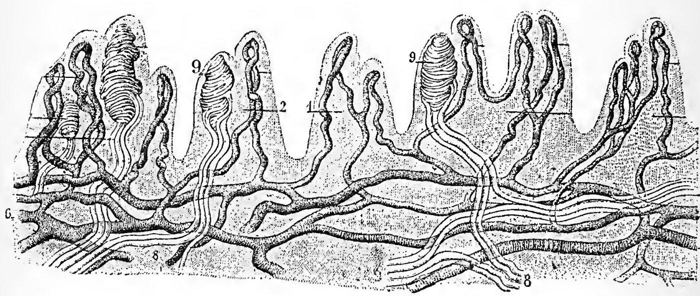


FIG. 51. — Papillæ of the palm of the hand. 1, with two looped blood-vessels; 2, with one loop and one touch-corpuscle, 9; the nerves, arteries, and veins are seen below (6, 8).

the skin are soft and pulpy, and need the protection of a drier and tougher covering, as apples and other fruits require it.

2. **Sensation.** — The skin possesses the sense of *touch*, by which we learn the shape, the size, the roughness or smoothness, and other things about the outside of objects. The skin is therefore called the organ of touch, as the tongue is the organ of taste. The tips of the fingers possess this power in a high degree, and are most used for the purposes of touch. The tip of the tongue is nearly as sensitive. Touch is perceived by means of numerous peculiar, small, roundish bodies, the *touch-cor'puscles*, situated in the true skin, just below the epidermis. They are found in the papil'læ. (See Fig. 51.)

The papillæ are placed in rows, forming little ridges, and the epidermis over them indicates the shape of these ridges, as may be seen at the tips of the fingers.

Other sensations, resembling those of touch, are felt by the skin, as that of *tickling*. The feeling of *pain* is distinct from these. The sensation of *heat* and *cold* is different from either.

The sensations perceived by the skin may be felt in other parts. Tickling is acutely felt in the throat; when substances get into the windpipe, the tickling becomes severe and produces coughing. The interior of the mouth has a keen sense of touch. Heat and cold are felt in the mouth more acutely than on the skin. Pain may be felt in any part of the body, except in the hair, nails, or epidermis. But on the whole these sensations are very little felt in health, except upon and by the skin. The pain at the moment a cut is made is scarcely felt below the skin, though after an hour or two, when inflammation begins, the whole wound smarts.

Among our commonest sensations are those of "feeling warm" and "feeling cold." They may be superficial (*i.e.* on the surface of the body) or deep. Every one knows the feeling of warmth which follows exercise.

If we suppose this sensation represents the state of the interior of the body, we have a very wrong idea; there is at most but the trifling rise of a degree or two in the internal heat. The true cause of the feeling is the flow or rush of blood to the skin, caused by exercise; the skin temperature, measured by the thermometer, actually rises from 10° to 20° after exercise; and the nerves of the skin take notice at once of the change.

Pain or discomfort is made of use to us in two ways. When felt internally (as in the stomach or head after eating imprudently) it is a warning "not to do so again"; but when felt on the surface (from pressure, pinching, burning, cold, or a prick, cut, or lash), it warns us to stand out of the way of danger. The feeling of cold warns us to put on more clothing; that of heat, to remove a part of the clothing; and the sensa-

tions of the mouth often warn us of dangerous food or drink.

3. **Perspiration.** — Each sweat-gland is surrounded by a network of fine blood-vessels (capillaries). The blood contains a large amount of water, part of which readily passes through the walls of the blood-vessels and of the sweat-gland, from which it pours out upon the surface of the skin. With the water there is passed a little salt, which gives the skin a salty taste after perspiring; also, some substances, partly vapors, and mostly unpleasant to the smell, which would be injurious to health if kept in the body. But perspiration consists almost entirely of water.

While the sweat-glands are actively at work, the oil-glands are also in action, so that the fluid covering the skin is a mixed one.

There is always a little perspiration coming from the skin, except when it is completely chilled and white. In cool weather little blood circulates in the skin, and the fluid upon the surface is so small in amount that it evaporates before it collects in drops; this is called "insensible perspiration." In hot weather, and when exercise is taken, the blood flows freely to the skin and causes abundant perspiration.

The amount of water which passes from the body in this way is considerable. A man of average size, at a moderate temperature of the air, loses from one to two pounds (pints) of perspiration daily, without perceiving it. By exercising vigorously in hot weather, from six to twelve pounds may be discharged. While sweating so profusely a person feels hot, but afterwards there is a feeling of great relief and a cooling of the whole system.

Fat people often suffer from the heat. Vigorous exercise has a strong tendency to lessen the superfluous fat, especially if a person drinks rather less than he is inclined to do.

HYGIENE.

Perspiration always contains some vaporous substances which the body needs to get rid of, and which, as we are warned by the sense of smell, are unwholesome to breathe. These vapors are also injurious if kept closely confined by tight-fitting clothing. Clothes ought always, but more especially in summer, to be made of loose material to allow the vapors to escape freely. The use of tight rubber clothing is most injurious. If the skin could be completely covered with rubber varnish, death would follow in a short time.

To avoid a disagreeable odor from the person, — which is much more common among "nice" people than they fancy, — let the skin be washed daily all over, using soap at points where odor is most noticed. Let it be remembered that woollen undergarments are least likely to take a bad odor from the body, while cotton or gauze ones are apt to become offensive in a day. The perspiration from the feet is often unpleasant, especially when rubber shoes are used. A wash of carbonate of soda in water may be useful for this.

Perspiration is often increased while we are in bed. It is therefore important that the bedclothes should be thoroughly aired in the morning, the pieces being laid apart and the windows opened, to remove the "close" smell which the clothes have, and which is unwholesome.

Blankets and bedding which have been used a long time ought to be washed. Such material as cannot be washed, as the cotton in bedspreads, must be thrown away. It is better not to use cotton-wool or batting at all for this purpose, as it absorbs the odors and exhalations of the body and retains them. Feathers do the same. For bedding which can seldom be washed the best materials are wool and hair; wool for the blankets, hair for mattress and pillow. Cotton is suitable for the washed clothes; linen feels cold to the skin, but in hot climates is a luxury.

Attention to the state of the skin is required, not merely

for the pupose of avoiding offence, but for reasons of health. Nothing does more for the health of the whole body than good care of the skin. A free, natural perspiration should be produced every day by exercise, and the products of the perspiration should be removed, with the dust, soot, and other accidental matters, soon after exercise.

An unwashed skin becomes covered with the substances here mentioned: the little openings or pores become filled, perspiration is checked, and health suffers. What happens to the general surface of the body may be plainly seen (in rather a worse degree) upon the nose or cheeks of unwashed persons; in those parts there are large oil-glands which get choked with their own secretions, and the dust or soot of the air getting rubbed into their orifices produces the appearance of black dots. From these the contents of the glands may be squeezed in the shape of something like a grub or worm. Young persons, even when cleanly, often suffer from pimples at these places. Much relief is got by pressing out the "grubs" with a watch-key; nor should soap and water be neglected. Exercise often does great good. Medical treatment is sometimes necessary.

At other parts the orifices of the glands of the skin are liable to become stopped up, or even grown over by excessive growth of cuticle.

The good effect of attention to the skin is often seen in the case of horses. A man who cares for his horses, and likes to see them fresh, spirited, bright-eyed, and ready to go, will not only feed them well: he will also see that their skin is not chilled by a cold stable; he will remember to blanket them when standing in the cold; and he will have them "groomed" or rubbed down thoroughly every day.

Many persons find it both pleasant and useful, after bathing, to rub the body with a coarse cloth or a flesh-brush as hard as can be borne.

It may be well to add here, that our toilet operations ought not to be performed in company. It is quite common, for

example, for young persons to pick their teeth (even with their fingers), to comb their hair with their fingers, to pick their faces and noses and ears, in the presence of others. Such actions appear natural to the one who does them, but to others they are disgusting, for they suggest a dirty and neglected body.

The old proverb, "Dirt is wholesome," has wisdom in it, if rightly understood. Play in the open air is wholesome; children cannot play freely and vigorously without sometimes tumbling on the ground. In some of our best games the players are liable to be soiled from head to foot. But after play there is time to wash: a dirty face, neglected finger-nails, unwashed neck and ears, frowzy hair, or muddy clothes, will not make a child healthier or happier.

In certain occupations workmen have to keep clean in order to avoid being poisoned. For instance, workers in lead and paint-grinders are liable to get particles of the poisonous dust on their hands and faces, from which it may easily get into their mouths, if they do not wash before each meal.

Soap contains fat or oil, combined with an alkali (soda or potash). When applied to the skin, its alkali dissolves some of the grease of the skin and softens some of the top layer of the epidermis; the lather then mixes with the dissolved and softened materials and enables us to remove them conveniently. Soap also removes common dirt (dust, coal, grease, etc.) from the skin.

The skin can be cleansed of the greasy secretion by rubbing with a dry cloth. The soap, however, does more thorough work, for it dissolves out some of the grease from the pores. Some persons need to wash the face with soap once or twice a day; others, less frequently.

Much of the soap now sold is adulterated with materials which do not help in cleaning. Much is made with rancid grease, and is injurious to the skin. Highly scented soaps may be suspected of impurity. There are soaps which appear to be very strong, owing to the great quantity of soda they

contain; such strong soaps are not good for the skin. Old-fashioned brown bar soap is not always made of pure material.

The ancient Greeks and Romans were very cleanly in their habits, and very fond of baths. Instead of soaping the body, they used to rub themselves with sweet oil, and then cleanse the skin by scraping and hard rubbing. But before doing this they took some vigorous exercise, by running, jumping, dumb-bells, ball-playing, and in other ways, so as to get the skin well covered with sweat; or at least, they would use a hot bath long enough to start the perspiration, and then would wipe, oil, and again clean the skin.

Good olive oil rubbed well into the skin does not leave a bad smell after wiping; it seems mostly to disappear, for the skin absorbs some of it, and that which remains on the surface can be wiped off.

Open-air bathing is to many one of the chief pleasures of summer, and it may be made as wholesome as it is delightful. Sea-bathing has some advantages over bathing in fresh water. The water of the ocean is peculiarly stimulating; that is, it seems to excite the whole system, increasing the appetite and making the muscles active, while the heart beats more strongly, and the skin is warm and glowing; and in addition to this, it puts the bather in high spirits, making him want to dance and shout. These good effects do not come at the instant of entering the water; the first feeling is one of cold and shrinking, which, however, soon passes off, and the glow comes on, or, as it is termed, the "reaction." In order to promote reaction, it is well to move about vigorously in the water. Those who react slowly or imperfectly should be very cautious about bathing, especially on beaches where the water is cold. Some persons are harmed rather than benefited, even by moderate sea-bathing, the effect being to make them languid and feeble.

We are best capable of reacting at times when we feel strongest, and when the body is well fed and well rested.

Before breakfast few persons can bathe in the open air without injury. The forenoon, at a reasonable interval after

breakfast, is the best time. Any time when we are very much tired is unsuitable. Immediately after a meal is a bad time. But a brisk walk, which does not fatigue, is rather a good preparation for bathing, only we should not sit down and cool off before going in, since "cooling off" may mean chilling, and enfeebling one's vital powers. Extremely cold water is dangerous for persons who are over-heated, and may cause cramps with great danger of drowning, or may bring on sudden and fatal internal disease.

It may be weakening to stay in too long. A good many, however, do this, partly for the pleasure, partly for the sake of the company they are in. *Twenty minutes* is about as long as most persons can stay in, and a great many ought not to remain more than ten, or even five. When the water feels decidedly cold, the time should be less. When one has been in too long, he begins to feel a little less warm, a little tired: if possible, he should come out *before* he feels so. To feel very tired after bathing is a bad sign.

Swimming is an excellent athletic pastime, and strengthens both muscles and wind.

SYNOPSIS.

The skin is composed of two layers, epidermis and derma. The latter only contains blood. The cells of the cuticle are formed at its deeper part, gradually approach the surface, and are at last dropped or washed or worn off. The outer layer of cuticle is the "horny stratum"; the deeper layer contains coloring matter. Blisters raise the epidermis from the derma: vaccination produces them; sunburn may cause either blisters or peeling of the epidermis.

The nails belong in structure to the epidermis; the whole nail rests on the derma. Hairs are analogous to nails; they grow from derma at the bottom of little pits (follicles), into which sebaceous glands discharge. Hairs, nails, and epidermis are repaired or restored; but if the true skin is destroyed, these are not restored. After deep burns true skin is not formed, but a tissue which shrinks.

The cutis (true skin) contains hair follicles, oil-glands, sweat-glands, nerves, and blood-vessels. The papillæ are projections of the cutis, in

which capillaries and nerve-endings are found. The fibres which form the tissue of the true skin can be hardened, by tanning, to leather.

The skin *protects* the nerves and blood-vessels, and the soft parts.

It *perceives* objects touching it, and their qualities; it is the organ of touch, and acts by means of the touch-corpuscles in the papillæ. Tickling, pain, heat, and cold are also perceived by the skin. Similar sensations may be felt in internal parts, but the skin takes the chief part in their perception. The feeling of heat after exercise is due to the flow of blood to the skin. Pain is a warning to be cautious.

The *perspiration* consists of water holding in solution common salt and other substances, some of which are vaporous; it passes from capillary vessels into the sweat-glands, and thence to the surface. The oil-glands act at the same time. In cold weather there is little blood in the skin, and the perspiration is so slight as to be unnoticed ("insensible"). At a moderate temperature one or two pints pass off in a day, insensibly: a much greater amount during vigorous exercise in hot weather — a practice tending to lessen fat, and give relief to the system.

The vapor of perspiration ought to escape freely; hence tight clothing is undesirable, and air-tight clothing injurious. Woollen is less liable to become offensive than cotton. The bed-clothes must be aired to get rid of perspiration-products. All bedding requires to be washed; cotton batting, in bedspreads long used, has to be rejected; and feathers after a while absorb much from the exhalations of the body.

Free perspiration should be sought daily by exercise; after which the skin should be cleansed. This frees the pores. Parts of the face are apt to show oil-glands choked with secretion ("grubs") and pimples; cleanliness partly relieves this; but hygienic and medical treatment is often needed.

"Grooming" the skin improves the health and spirits of man and beast. A brisk rubbing with a coarse towel or flesh-brush is invigorating. Do not perform your toilet in company. Dirt got from rough play does no harm; neglected dirt does no good. Uncleanly paint-grinders are liable to get poisonous particles into the system.

Soap dissolves the grease from the skin by means of its alkali, and helps remove it by its lather. It does more thorough work than a dry cloth. Much is adulterated with injurious material; some is too strong in alkali; perfumes are suspicious. The ancients used oil and hot water, with wiping.

Sea-bathing is more stimulating than bathing in fresh water. The first feeling is that of cold; reaction gives a feeling of warmth; there are always some who react poorly, and are liable to be injured by the bath. Reaction is best when we are feeling best: not before breakfast, or when we are tired, or soon after eating. Very cold water may cause cramp. The time that persons can stay in differs much, according to their constitutions.

SUGGESTED QUESTIONS.

Two layers of skin. True skin. Cuticle. Pricking with needle. "Barking" the skin. Microscopic structure of cuticle. Cells: form, point of formation, loss. Washing, sweating. Horny layer. Thickening. Colored layer. Races. Tanning. Blisters. Vaccination. Scarlet fever.

Nails and hair: relation to cuticle. Root of nail: bed, movement during growth. Hair: follicle, relation to derma, oil-glands. Loss of hair or nail. Destruction of true skin. Scars. Burns. Sweat-glands. Pores.

Cutis: thickness. Structures contained in it. Blood-vessels. Papillæ. Fibres.

Uses of the skin. Protection. Sensation. Touch. What we learn by touch. Where best developed. Organs of touch: where situated. Papillæ. Various sensations like touch. Sensations, as perceived inwardly. Pain of a cut.

Feeling of warmth or cold, where perceived. Relation of exercise to this feeling. Actual heat produced in exercising. Use or value of sensation of pain, heat or cold, etc.

Perspiration: process of its production, composition, mixture. Insensible. Amount. Effect of exercise. Fat people.

Hygienic value of perspiration. Vapors of body. Tight or air-tight clothes. Woollen *vs.* cotton underwear. Feet. Bedding. Washing bed-clothes. Comparison of materials for bed-clothes. Effect of cleanliness, associated with free perspiration; effect of neglect; pores of face. Grooming. Rubbing down. "Dirt is wholesome." Lead-poisoning.

Composition and action of soap. Adulteration. Various ways of cleansing the skin. Oil. Bathing. Reaction. Difference in individuals. Time for bathing. Cold water. Length of a bath. Swimming.

CHAPTER VII.

VOICE. — COLDS.

THE VOICE.

The voice is heard in speaking and in singing. It is produced in the *lar'ynx,* and its sound is modified by the upper throat, tongue, palate, teeth, and lips. To show that it is produced in the larynx, place one or two fingers on the side of the larynx ("Adam's apple"), and pronounce or sing a few words in a strong voice; a thrill or vibration of the throat is felt when the voice is used.

The larynx is a box-like structure of cartilage at the upper part of the windpipe. There is at its mid-point a sort of valve, which ordinarily stands wide open, allowing the breath to pass freely; but we can when we choose make the opening narrower, in which case the air in passing makes a noise like the sound of some musical instrument. The valve can be compared to a pair of half-curtains, which usually stand apart, but can be brought together by the edges. The edges are the *vocal cords.* When they touch, the breath is prevented from passing; when separated, they leave between them a narrow slit, called the *glottis,* in the shape of a pointed oval, with smooth, clean-cut edges.

Every sound of the voice has a musical pitch. The larynx (with the throat, mouth, etc.) forms a sort of musical instrument, resembling an organ-pipe, but with this difference, that the wooden slit in the pipe gives only one note, while the larynx, by changing the shape of the glottis, can give an immense variety. High notes are produced by drawing the cords

tightly, so as to make the glottis narrow; low notes by widening the opening.

The motions of the vocal cords are produced by several

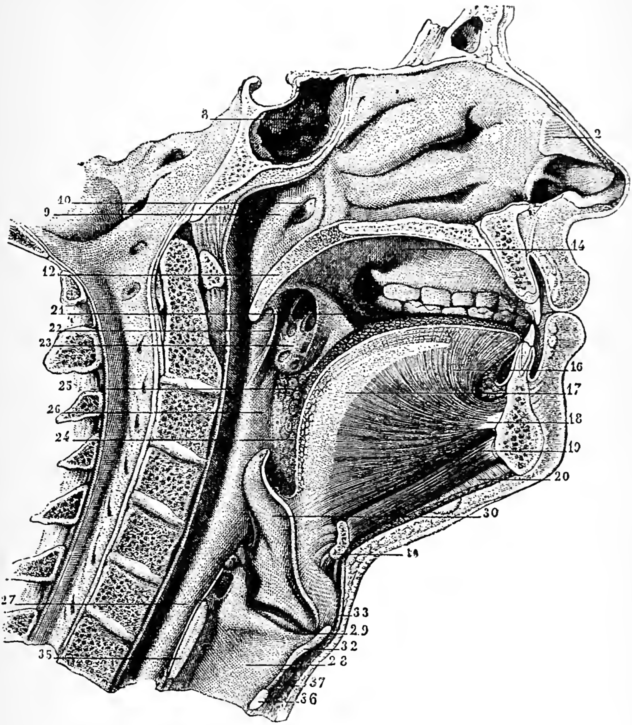


Fig. 52. — Vertical section of the mouth, left nostril, and pharynx. 2, cartilage of nose; 8, cavity in the bone; 9, posterior cavity of nostril; 10, opening of the Eustachian tube; 12, veil of the palate; 14, vault of the palate; 16, tongue, forming the floor of the mouth; 17, base of tongue; 18, 19, 20, muscles; 21, 22, folds between which (23) the tonsil lies; 24, tongue, where it forms part of the pharynx; 26, pharynx, near larynx; 28, cavity of larynx; 29, points nearly to the vocal cords; 30, epiglottis; 32, thyroid cartilage, cut; 33, its upper border; 35, 36, cricoid cartilage, cut; 37, membrane joining cricoid and thyroid cartilages.

pairs of small muscles, which we move without knowing it though we are conscious of intending to produce the effect.

Fig. 52 shows the upper respiratory passages. The air, passing from the lungs over the vocal cords (29), forms a musical note; the sound passes upward, and escapes freely when the valve called the *epiglottis* (30) is drawn forward. The connections of the tongue with the larynx and epiglottis are seen to be very close.

The Adam's apple is much more prominent in men than in women or children. It begins to develop at the time when the voice changes from the boy's treble to the young man's bass or tenor. A boy should not practise singing at the period of change; it may injure the voice. The average range or compass of women's and boys' voices is an octave above that of men.

The quality of the voice — clear, sweet, squeaky, rasping, "throaty," hoarse, or otherwise — is not due to the larynx alone, but is affected by the shape of the pharynx, nostrils, and mouth. These organs are partly well formed by nature, but we have some power to change them by voluntary muscular action. In training the voice, the teacher shows how to hold the parts, and by gradual practice accustoms the pupil to form the throat and mouth into a well-sounding musical instrument. It is far easier to do this before the age of twenty than afterwards.

Besides all this, a person must have good lungs to sing well. Singing is one of the most healthful exercises; it brings into vigorous activity all the muscles that are used in breathing. It also has a favorable effect upon the circulation and digestion. In order to sing, speak, or read well, a person must hold the head erect, must sit upright (or better, stand), and must have the body free from confining garments. One should not practise when the throat is sore, or when the stomach is full, or when one is very tired.

The voice is a good test of the state of a person's health, and a singer can neither sing so high nor so well when indisposed. Professional singers take the greatest possible care to avoid colds, and if they catch one, they have it cured as quickly as possible.

COLDS.

The avoidance of colds is more important than is generally supposed. It is weakening to have them, and it is a sign of weakness of constitution to have them often. There are also some troublesome and dangerous diseases which are brought on by colds.

A "common cold" is an inflammation of some part of the mucous membrane, — that soft, red inner-skin which lines all the air passages, and all the food passages, and also the middle ear, the front of the eye, and the cavities in the forehead bones.

Sore throat, cough, headache, fever, inflamed eyes, deafness, loss of taste and smell, diarrhœa, want of appetite, and aches all over the body are well-known symptoms, noticed at different times. Many are so affected by a cold that they are unfit to be out of bed. Influenza is a severe sort of cold which attacks large numbers of persons at once.

Deafness is sometimes present in case of a cold. If the person recovers completely, the deafness passes away; but if the throat remains more or less sore, the ear trouble is apt to continue, and thus, by degrees, many persons become deaf. Earache, a severely painful affection, is often due to a cold which affects the middle ear.

The eye is covered in front with a delicate mucous membrane, which also lines the lids. It can easily be seen by turning back one lid. When dust gets into the eye, the membrane becomes reddened. Dust, wind, and a cold in the head often cause *inflammation* of this membrane, or "a cold" in the eye. The tear passage, which connects the eye with the nose, is often the channel by which a cold travels up into the eye.

An exposure to cold, which in our northern climates causes a cough, is apt in hot countries to cause a disease of the liver or bowels. Some very painful and fatal affections of the digestive organs are caused, in hot countries, by carelessly sitting down in a draught to "cool off" when overheated; and the same may occur in the heat of our own summer.

One cold often makes a person the more liable to take another, for it leaves a person somewhat weaker and more "tender"; or else it may not be wholly cured, and may lurk, ready to break out again, in some corner of the throat, ear, or nose. Some seem always to have a cold, or to be just going to; while others scarcely ever have one, and if they do it passes off in a day or two.

Consumption not infrequently begins with a severe cold, which is allowed to run on uncured for weeks or months. The two diseases are not the same; but the cold may lay the foundation for the more serious complaint. In other persons the lungs, after such long colds, become permanently delicate, and will not endure to breathe the out-door air at night; they acquire a chronic bronchitis. The measures which are useful in enabling people to resist colds are also useful in preventing consumption.

A chronic (or continuous) sore throat often plagues those who speak much in public. It is largely due to their using the voice in a strained, unnatural way. It is not so likely to be produced by *speaking* as by *reading*. But practice in reading aloud, under good instructors, is beneficial to both throat and lungs; like other exercise, it ought to be continued nearly every day, and ought to be very moderate at the beginning; though by practice a person may be able to read for hours. Singing is much harder work than speaking or reading. It is very beneficial when performed correctly and with an avoidance of false, strained, unnatural efforts. It is a great art in a teacher to enable a pupil to sing or read *easily*.

Among the chief causes of colds are exposure to cold, to dampness, to draughts of wind, to sudden changes of temperature; improper clothing is also a cause. Instances are: going from a warm room to sit in a cold one, or into a chilly, unwarmed hall; sleeping between sheets that are not thoroughly dried; sitting in wet clothes or damp stockings; changing from thick to thin clothes too early in spring. Too thick clothes indoors, in hot rooms, make persons "tender," or

liable to take cold. A hot, dry room may bring on a cold in the head.

"The heads of some children are oftentimes vigorously washed without being thoroughly dried; they are allowed to remain in water unduly long; their arms and chest are left uncovered in weather in which strong men are clad in beaver-cloth and women in furs; they play about the streets and sit down, when tired and warm, on the damp, cold stone steps of city houses; they are held thoughtlessly by open windows on a cold day; they are warmly clad by day, but insufficiently covered by night."[1]

The dress of women is often quite insufficient to keep them warm.

Those who live entirely in the open air by day and night, in a pleasant climate, are usually free from colds. The open air is one of the greatest strengtheners of the system. Even in bad climates, like that of the Atlantic States in winter and spring, it is best to spend a great deal of time out of doors; two hours a day if possible, and much more, if convenient, on most days.

The sunshine and dry air are good — fog, damp, high winds, and dust are bad — for those who take cold easily. Plenty of good food and exercise are good; loss of sleep and overwork are bad. If a person can bear a daily cold sponge bath (and most can), it will lessen the delicacy or tenderness of the skin, and enable him to resist cold better. The weaker parts (as the throat, in some persons) should especially be thus bathed. Very pure air in the house is desirable. The temperature of 62° to 65° F. is probably the best for houses, and 70° should be a maximum. Our houses in America are usually kept too warm in winter, which makes our countrymen delicate. The Europeans are comfortable at 60°, or a little above it.

The systematic practice of deep breathing, as described on page 76, is most useful, both as preventing colds and as developing the voice.

[1] Dr. St. John Roosa.

Many physicians recommend that the body should be clothed in soft flannel from head to foot at all seasons. Some persons find their health much benefited by this plan; it is a preservative against rheumatism and colds. Others, however, appear to be sufficiently robust not to need flannels at all. In this respect, as in many others, there is great difference in individuals.

Many delicate persons cannot use cold baths, but are benefited by warm baths. The water, in such cases, must be warm enough to feel comfortable, and the room must also be warm. Such persons cannot bear cold weather well.

The "Turkish bath" requires an extremely hot room, in which people sit and sweat for a while, and then are rubbed down with soap and hot water, after which they jump quickly into a tank or pond of cold water for a few seconds. The cold water prevents taking cold after the bath. The Russians have the room full of hot steam; and when they have sat long enough, they run out and jump into snow or icy cold rivers. This would be a little too violent for us.

The Turkish bath is a good preventive of catarrhs or colds. Those persons who are subject to head colds or affections of the ear may omit the cold plunge and the shampooing of the head.

SYNOPSIS.

The voice is produced in the larynx and modified in the upper air passages. The sound-producer consists of the edges of the two thin curtains (cords) which vibrate while the air rushes through the slit between them (called the glottis). The tension of the cords and shape of the glottis can be changed by muscular action, producing different musical notes. The epiglottis protects the larynx from the entrance of substances in swallowing. While the voice is changing and the Adam's apple enlarging, boys should not sing much.

The quality ("timbre") of the voice is affected by the pharynx and parts adjacent. In training the voice one learns to hold the parts correctly.

Singing is very wholesome. The dress in singing must be easy, the

posture erect, the body free from fatigue or illness, and the stomach not full.

Colds are weakening, and often dangerous. They consist of inflammation of the mucous membranes of various regions, with many symptoms, chiefly of the respiratory and digestive organs, eyes, and ears. Deafness often originates in colds. The liver and bowels, in hot countries, are often affected where the respiratory organs would be in cold countries.

One cold prepares the way for others; or even for chronic bronchitis, or consumption. Chronic sore throat may be due to improper use of the voice.

The causes of colds include chills, draughts, improper clothing, and excessive heat of rooms. Life in the open air, sunshine, dry air, cold washing or bathing, cool rooms, practice in deep breathing, and things which strengthen the system, help to prevent colds. Flannels and Turkish baths are useful to many.

SUGGESTED QUESTIONS.

Voice: production, modification. Vibrations. Larynx. Vocal cords. Glottis. Musical pitch. Muscles. Epiglottis. Development in boys. Adam's apple. Quality of tone. Training. Singing: effects; conditions to be observed in practice.

Colds. Definition. General symptoms. Ear. Eye. Digestive organs. Late effects: disease of lungs; chronic sore throat. Causes: "exposures" of many sorts, heat, cold, dampness; injudicious management of children. Preventives; air, climate, bathing, temperature, lung-exercise, clothing.

CHAPTER VIII.

THE NERVOUS SYSTEM.

WE have seen how the body and the members are made to move; that is, by the muscles. The heart contracts (beats) because it is a muscle. The blood-vessels are encircled with minute muscles, which aid in propelling the blood. The stomach and bowels have much muscular fibre, with which the food within is pushed onward. Besides these functions, there is the very important one of breathing, which is dependent on muscular action. But muscles of themselves will not do work. They require to be ordered and guided and regulated, and this is the duty of the nervous system.

Man is also endowed with what is vulgarly called his "seven senses" or "seven wits"; they are, in reality, five, — sight, hearing, smell, taste, and touch. All these depend on the nerves, each sense having an organ with a peculiar structure, which belongs to the nervous system. All pain and all pleasant sensation depend on the nerves.

The brain also — the organ of the mind — is a part of the nervous system.

Finally, the secreting power of all the glands, from the liver down to the little sweat-gland, is under the control of nervous influence.

The nervous system is thus seen to be connected with four of the chief functions of life, — those of *thought, sensation, motion,* and *secretion.* It has the entire control (so far as the body has anything to do with it) in the case of thought and sensation. It has the regulation and direction in the case of motion and secretion.

The nervous system in a man may be compared to the gen-

eral of an army, with his officers and scouts. He himself is the brain; he alone knows what has been done, and what is to be done. His scouts and sentries are his nerves of sight, hearing, and feeling. His officers are the nerves of motion, conveying orders to the regiments and companies, — the muscles. His commissary agents are the nerves regulating the glands and stomach.

It is easy to see that the nervous system is the highest part of the bodily frame.

ANATOMY.

The nervous system, as a whole, is chiefly built up of *fibres* and *cells*, both of which structures are so small as to require

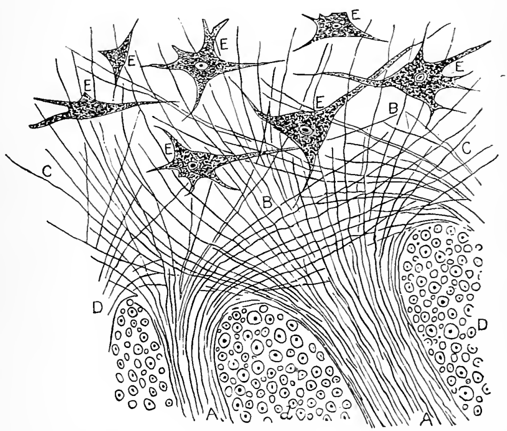


FIG. 53. — Section of part of the spinal cord. *A*, *A*, bundles of nerve-fibres; *B*, *B*, *C*, the same, dividing into separate fibres; *D*, circles showing nerve-fibres, cut across; *E*, nerve-cells.

a microscope to see them. Cells are commonly found in great numbers together; and fibres are usually united, many together in one bundle or hank, forming what looks like a white thread. One such bundle is what is commonly called "a nerve."

A mass of nerve-cells has a pinkish gray color, as may be seen by examining the surface of an animal's brain, the outer

layer of which is composed of such cells. Such a mass is called *gray matter.* A group of cells is a *ganglion.*

There is much variety in the forms of the cells, but each consists of a little sac or bag, filled with a peculiar chemical substance containing much phosphorus. A small body called the *nucleus* (kernel) is found in the interior. Cells have one or more branches; to some of the branches nerve-fibres are attached.

The nerves, outside of the brain and spinal cord, contain no cells. They are supported (being delicate, soft structures) by strong sheaths of white fibrous tissue.

The nervous system can be divided into two parts. One of these, — including (*a*) the brain, (*b*) the spinal cord, and (*c*) the nerves which belong to the muscles, skin, and organs of sense, — is called the *cerebro-spinal system,* or division of the nervous system. The other division belongs chiefly to the internal organs and the circulation, and is called the *visceral system:* it will not require much of our attention.

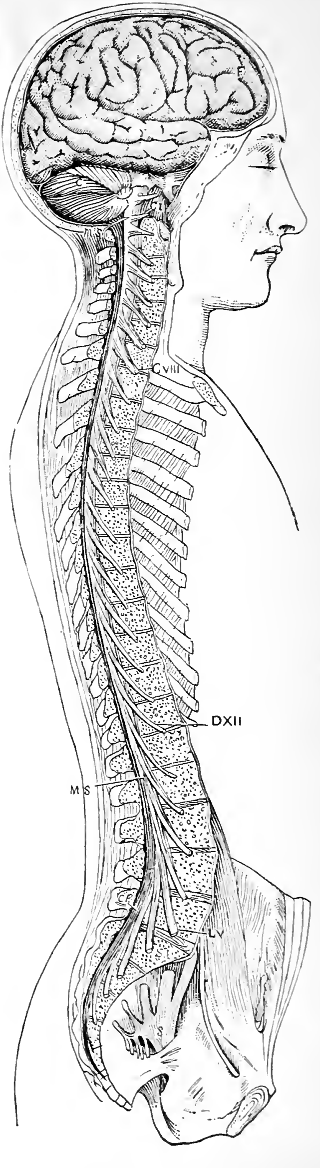
CEREBRO-SPINAL SYSTEM.

The brain fills the entire cavity of the skull; not merely the forehead part, but also the parts which are covered with a growth of hair.

Under the skull there is a firm, tough, rather thick membrane, which acts as a protection, but is not attached to the surface of the brain. When this membrane is cut away the brain itself appears, displaying a soft, grayish mass, looking as if it were composed of a coiled-up heap of soft materials. This peculiar appearance is due to the fact that the outer layer of gray matter (about as thick as a piece of silk velvet) is folded or tucked in a complicated manner. The folds are called *convolutions.*

The brain is divided into three parts, — the *cer'ebrum,* or brain proper; the *cerebel'lum,* or "little brain"; and the *cere'bral ganglia.* The cerebrum, in man, is much the largest part, and

is the only part seen from above. The cerebral ganglia are beneath; the cerebellum is behind and beneath.



The whole structure is very plainly divided into a right and a left portion. A deep groove or parting extends from the front to the back of the brain, forming the right and left *cerebral hemispheres.* A similar arrangement exists in the cerebellum. The hemispheres, both of the cerebrum and cerebellum, are very closely united by their deeper parts, both with each other and the cerebral ganglia.

The brain is the organ of the mind. Strictly speaking, this statement refers to the *cortex* of the cerebral hemispheres, the cortex being the thin outer layer of gray matter. The cortex covers all the convolutions, and dips down into the infoldings of them; the convolutions, therefore, greatly increase the amount of the gray matter of the cortex. We can estimate the intelligence of an animal from his brain, by observing how numerous the convolutions

Fig. 54. — Brain and spinal cord. *C*, cerebellum; *V*, fifth pair of nerves (for the face); *MS*, lower end of cord; *CVIII*, eighth cervical nerve; *DXII*, twelfth dorsal nerve; *LV*, fifth lumbar nerve. The nerves are seen arising from the spinal cord.

are. Stupid animals (as the rabbit) have few or none. In men of great intellect, they are more numerous and deeper than in men of weak minds.

The size of the cerebrum proper, as compared with that of the cerebral lobes and the cerebellum, affords another test of mental power. In man, the cerebrum covers the cerebellum; in the quadrupeds, it is not large enough to do so; in fishes, it is so small as to be insignificant.

In speaking of the size or weight of "the brain," we commonly include all three parts; so that the size and shape of a "brain" is the same as that of the whole interior of the skull containing it. In this sense, a fish's brain is stated to weigh $\frac{1}{5000}$ or $\frac{1}{6000}$ of his body, a bird's, $\frac{1}{200}$, and a man's, $\frac{1}{46}$. The brain of man is not only *proportionally* large; it is *absolutely* larger than that of any animal except the whale, the elephant, and the dolphin, and is nearly as large as these. One of the largest brains — that of the great naturalist, Cuvier — weighed 1831 grammes.

The cells of the brain have branches (Fig. 53). From these branches nerve-fibres pass, which serve to connect the cells. The fibres run in many directions, and their study is one of the most complicated parts of the anatomy; but we know that they form connections between the right and left halves of the brain as well as between cells of the same side. The fibres also pass down to and through the cerebellum and cerebral ganglia. There is much gray matter in those organs; they are not believed to be the seat of mental action, but to be connected with the senses of sight and hearing, the power of balancing, and that of regulating movements.

It is impossible to prove by dissection that any single fibre starts from a brain-cell and goes down through the ganglia into the spinal cord. Nevertheless, it appears evident that a large number of fibres do run this course. They pass out from the skull by a hole in its base, and, united, form the *spinal cord*, which lies in the protected, tube-shaped cavity of the spinal column, extending down to the second lumbar vertebra.

The spinal cord (or "the cord") has many cells, besides the fibres already mentioned; it may for this reason be regarded as an extension of the base of the brain downward. We may look upon the brain and cord as one organ, the whole of which

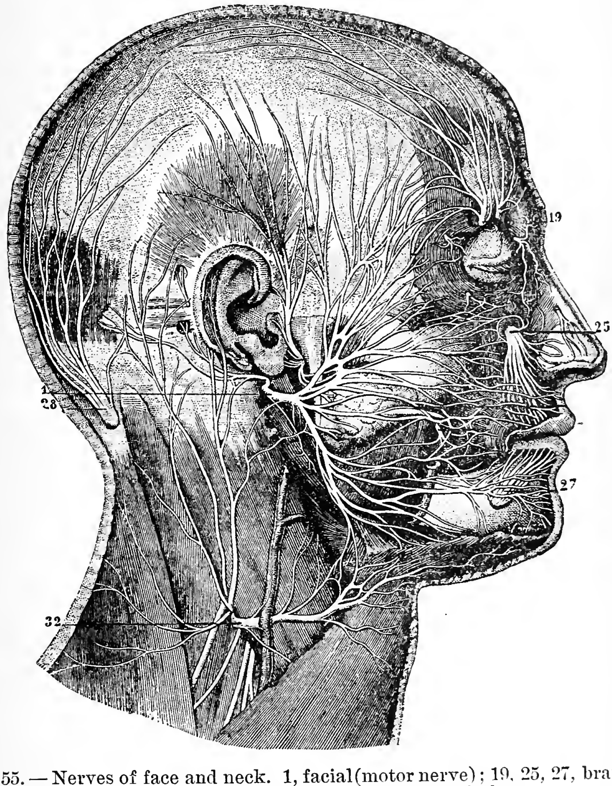


Fig. 55. — Nerves of face and neck. 1, facial (motor nerve); 19, 25, 27, branches of trifacial (sensitive nerves); 23, occipital.

is of use in governing *motion*, while only the upper part (cerebral hemispheres) is connected with *consciousness* or with *knowledge*.

Between every two vertebræ there is an opening on the right

side, and one on the left, out of which pass a pair of nerve-bundles, one on each side. These bundles of nerves pass to the right and left respectively, in the direction of the ribs, and, dividing, go to various muscles and other parts. At the level of the arms the bundles are much larger, to form the arm-nerves; at the small of the back they are still larger, in order to supply the great nerves of the legs. These are termed the *spinal nerves.*

There are also nerves coming directly from the base of the brain, called *cerebral nerves.* These proceed to the face, neck, and forehead; also to the eye, ear, nose, and tongue, to provide for the special senses.

GANGLIONIC OR VISCERAL SYSTEM OF NERVES.

This system regulates the inner parts of the body and the blood-vessels, parts over which we have no direct control.

A "ganglion" is a group of nerve-cells. There are hundreds of them inside of the body, of various sizes; they are connected with each other and with the cerebro-spinal system by nerve-fibres, and they send nerves to all the *viscera* or internal organs (of which the stomach, intestines, liver, kidneys, heart, lungs, and brain are the chief), and also to the blood-vessels and glands.

The name "sympathetic nervous system" is frequently applied to these nerves and cells.

PHYSIOLOGY OF THE CEREBRO-SPINAL SYSTEM.

Each nerve has the duty of carrying messages, either *from* the brain and cord or *to* it. How this duty is performed is not fully known; their action reminds us of the action of telegraph wires; but it seems certain that the agent or power that carries the messages is not electricity.

Messages are carried outward, to the muscles and glands; they are brought inward, from the organs of sense and sensation, and carried to the brain.

A single nerve-fibre has only one duty to perform; it transmits either in the inward or the outward direction, but not both ways. Yet a bundle of fibres (such as is commonly known as a nerve) may contain nerves of both sorts. The two kinds seem to be alike in structure.

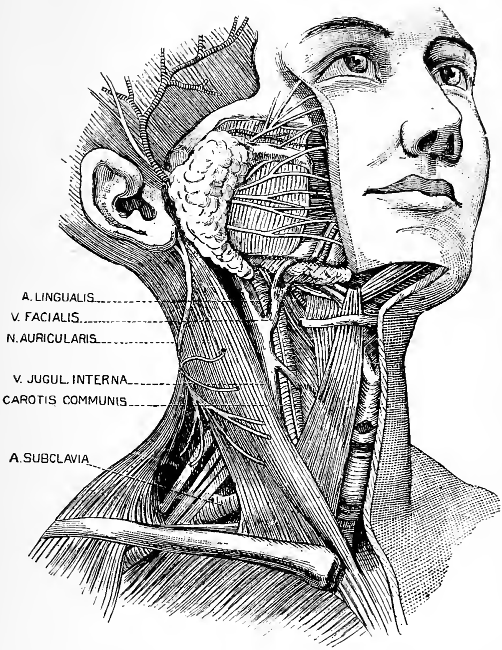


FIG. 56. — Nerves of face and neck. The parotid gland is shown in front of ear. Arteries (*A*), veins (*V*), muscles (*M*), nerves (*N*).

Sensation. — This includes the *special senses* (sight, hearing, smell, taste), the sensations of *touch*, and *heat*, and *general* sensation.

Special senses are treated elsewhere.

The sense of touch belongs to the skin and mouth. It resides in certain singular small bodies, which are found in the skin, and are connected with nerves. They are most

numerous where the sense is most acute, as on the finger-tips, the palms and soles, the lips and face, the tongue and interior of the mouth. This sense is surprisingly useful to persons who are deprived of sight. By practice they become so skilful as to read the letters on types by touching them; they also read books printed in raised letters for their especial use, by passing their fingers over the letters. (See Fig. 51.)

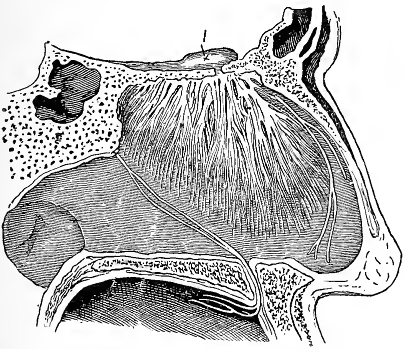


FIG. 57.—Nerve of smell (olfactory nerve) at *I* is on the floor of the brain-cavity; the fibres descend from it, through the bone, spreading on the wall of the nostril.

The feeling of heat or cold needs no special explanation.

General sensation is "that which is experienced when a nerve is laid bare and touched." The student is not likely to know this from experience; he may, however, understand that it is a sort of feeling which does not (like touch or the sense of heat) give any particular information, but is only a feeling; and that when it becomes intense it is *pain*.

If an ordinary nerve in a limb is cut across, or tied tightly, or even pressed upon, it can no longer transmit sensations. If we then touch a part of the skin to which this nerve goes, the touch is not felt; the part seems quite dead. This is often experienced when the arm or leg "goes to sleep."

A cut nerve may, in healing, so reunite that the "feeling in the parts" is entirely restored.

Voluntary Motion.—This is caused by the contraction of muscles, acting under the direction of an order sent from the brain, by means of nerve-fibres. Some fibres pass directly from the brain to the face; others first pass into the spinal cord, then go from the cord by spinal nerves.

Cutting, tying, or pressing a nerve of a limb takes away the power of moving the muscles to which that nerve goes. This would at first sight appear to show that one and the same nerve is used both for feeling and motion. We can, however, prove that this is not the case. The nerves can be traced back to the spinal nerves; these can be traced to the points where they leave the spinal cord, and there each single nerve is seen to be composed of two bundles of nerves. One of these bundles (their proper name is *spinal nerve-roots*) is composed of nerves of sensation; the other, of nerves of motion, as has often been proved by experiment. For if the front or anterior root be cut, in a living animal, the effect is paralysis or loss of power of motion; if the back or posterior root be cut, the power of sensation is lost.

Paralysis is loss of power of motion. It is sometimes caused by disease in the brain, as in apoplexy and tumors of the brain. When the back (*i.e.* the back-bone) is broken, the spinal cord is pressed so that the parts below the injury are paralyzed. If the spine is broken in the neck, the "neck is broken," and death occurs very quickly.

Reflex Motion. — The muscles of the body, which regularly obey our wishes, will act, in certain cases, independently of the will. If a sudden motion is made to strike a person's face, the muscles of the eyelids act suddenly and close the eyes; and it is almost impossible to prevent their doing so, even if we know that the blow is a friendly one and not intended to strike the face. Another act which we often try hard to prevent is that of coughing or sneezing when dust gets into the throat or nose. It would seem that Nature sometimes takes matters into her own hands and makes us do certain things before we have time to think how necessary they are.

Many actions of this class can be performed without the help of the brain. This is proved by the experiment of removing the cerebral hemispheres of a pigeon's brain. The creature lives and can be made to eat, but he is extremely stupid and does nothing of his own accord. If thrown into the air, he

flies. A frog treated similarly can swim and jump very well, but seems to do nothing of himself. In such cases, it is believed that the gray matter of the cerebral ganglia and the spinal cord acts, and sends messages to the muscles. The process begins when the animal's skin is touched; then sensation is carried by nerves to the cord and ganglia; then the ganglia, aroused, send back an order to the muscles, — the animal all the while being incapable of knowing anything about what goes on.

What is the nature of nervous action? We cannot be positive, but it is believed that a certain force is produced in these cells, and that the fibres carry the force to the muscles, to order them to work. The brain contains a great many millions of the cells, many of which are connected with the acts of thinking, remembering, seeing, hearing, and other mental processes, while others have the power of ordering the muscles to move. When a person "uses his brain," the cells (or some of them) become more active than usual. When we move a finger, some cells in the brain must first become active, and must produce an order, which is sent down along some nerve fibre or fibres to the proper muscle of the finger.

This process may be compared to a man firing a gun by pulling a string. The man represents the cells in the brain; the string, the nerve-fibres; the lock, the arrangement by which the nerve is connected with the muscle; and the barrel with its charge, finally, represents the muscle with its own power of action.

Mental Action. — The faculties of the mind are many, and comprise all the powers of sensation, perception, action, thought, memory, and speech.

All powers are brought into action by the aid of the cells found in the gray matter of the surface of the cerebral hemispheres. We do not know that they are ever exercised without these cells, in our life upon earth.

The brain, each and every part of it, is dependent on a good supply of fresh, pure blood for its action. The same is true of

every other organ and part of the body; but in no other part does such a striking effect occur when the circulation is stopped. The effect is, that the person loses consciousness, or "faints"; all the actions of the mind cease instantly, and the body falls like a corpse.

In *sleep*, the circulation of blood in the brain is not wholly cut off, but only lessened. The pulse beats more slowly and less strongly. In a very deep sleep without dreams there is least blood in the surface of the brain; in light sleep, or in dreaming, there is more blood, but less than when awake.

In reading the list of the mental faculties given above, the student may have doubted whether it was right to include "speech and actions" as mental faculties. It should be said, therefore, that there is the strongest proof that such is the case.

By "speech" we mean the power of *intelligent* utterance of thought, such as no beast seems to possess. Certain birds have the power of uttering words, in imitation of man, but it is very doubtful whether they know the meaning of them. We say that they have not mind enough to understand. Children are to some extent like these birds: they can learn words more easily than meanings. There is a remarkable connection between certain parts of the brain and the faculty of speech, as is seen in the fact that disease affecting the surface of the brain at the left temple regularly produces a loss of power to talk. And further: the brains of monkeys (the highest in development of all animals, next to man), though exceedingly like the brains of man, are yet distinctly imperfect in that very region (at the left temple) where man's power of language seems to reside.

As regards "action," it is true that certain actions seem to require very little or no attention from the mind, such as walking or riding. But there are other muscular acts which are highly intellectual, as drawing, painting, sculpturing, playing musical instruments; even the blows of the blacksmith's hammer and the strokes of the woodman's axe have to be given with a great deal more judgment than people suppose. To crown the argument, it has been found that disease or injury

of certain parts of the surface of the brain hemispheres causes paralysis of the muscles of certain parts of the body.

HYGIENE.

The brain is affected by the ill-health of many other parts of the body, and no part more frequently causes such disturbance than the stomach. Over-eating stupefies the mind; bad digestion often makes the mind irritable or dull. It is necessary that persons who wish to do good brain-work should have good and regular habits of eating. Constipation is a very disturbing and weakening state, particularly in its effect in dulling the mind for the time. Neglect of exercise has a similar effect.

Probably no one thing is so necessary for the health of the brain as sleep, — sound, natural sleep, neither made heavy by drink nor made light and dreamy by tea or coffee. During sleep the brain quietly repairs itself after its waking labors. We do not know very well what takes place, but we do know that a brain which was tired out with work becomes, after sound sleep, fresh, strong, and ready for new tasks. The morning ought to bring a feeling of new life and power; if it does not, — if we wake tired and discouraged, — there is something wrong. It may then be that we were over-tired on the day before and have not yet got rested, or we have been up too late, or have eaten unsuitable things.

Sleep must be taken regularly. A time being fixed for bed which will allow for plenty of sleep, we should keep to the hour. By maintaining a habit of lying down and closing the eyes at the same time every evening, we soon find that we are fully ready for sleep at that time. Once in bed, waste not a moment, but drop off to sleep at once.

Different persons require very different amounts of sleep. Young infants sleep almost all the time; children of four or five, nearly half the time; those of ten or twelve, ten hours; at the college age, most students require eight hours; many

full-grown men sleep less; and in old age many sleep much less. Persons may, for years, take less sleep than they need; the effect is a gradual weakening.

In order to have sound, healthy sleep, young persons should go early to bed, on a light supper. If older persons sit up four or five hours after supper, they often require a light lunch before bed.

Bedrooms must be aired before they are slept in, and to keep the air fresh a window should generally be left partly open, even in moderately cold weather. Judgment should, however, be exercised; there is nothing gained for health by having the water freeze in the pitcher while we sleep. A room kept at the day-temperature of 65° or 70° is not suitable for sleeping, except in the case of infants or feeble persons: it makes a person delicate.

Pure air by day is also very necessary for the health of the brain. Scholars can work better in a well-ventilated room, because purer blood is then sent to the brain; in close, crowded rooms we grow sleepy, because the impure air makes impure blood, which does not give the brain proper support.

The best time for hard study is generally the forenoon; later in the day we cannot always work so effectively. Study must not occupy the hours of sleep; if it does, we generally "have to pay" for it next day. Study before breakfast agrees well with many; others ought not to study or exercise before eating something.

EFFECTS OF ALCOHOLIC DRINKS UPON THE NERVOUS SYSTEM.

There is no part of the body upon which the effects of alcoholic drink fall more directly than upon the nervous system. These effects are such that they can be seen and their nature understood with ease. The alcoholic beverages, when swallowed, are absorbed more or less quickly by the capillary blood-vessels of the stomach. They pass thence to the liver, then to the heart, where they are sent out, in the blood, to all parts of

the body. In short, they take the same course that water will when drunk. In a very little time they reach the brain, where they produce some effect at once.

One of the first effects is that of increasing the amount of blood circulating in the head. This will, of itself, sometimes interfere with sleeping when sleep is wished for; not a matter of very great consequence compared with the other effects.

Besides this, alcohol has a special power to affect the brain; which power may in some cases best be called medicinal, in other cases poisonous or narcotic.

As regards the *mental faculties*, it has often been supposed that wine and similar drinks sharpen the powers of the mind, awaking or spurring it up and giving it increased quickness and clearness. Upon this point we ought to make a distinction. Where people are drinking and enjoying themselves in each other's society, much is said that would not be told if all present were quite sober; much is said that seems bright and witty to those present, because those who listen are themselves a little "fou," as the Scotch say (*i.e.* foolish), but which to a sober outsider seems silly. Whether conversation is made brighter and wittier by this "convivial" use of wine, is a matter which needs no great amount of discussion here. Whatever the effects, they mostly pass off during a night's sleep, and the men awake next morning, sometimes with more or less sickness at the stomach, and headache, sometimes with nothing apparently unusual about them.

Drowsiness or stupor are later effects of alcoholic drinks. For a person who has been drinking heavily, sleeping is therefore a natural resort; and if he has nothing else to do, — if no business or duty calls upon him at once, — sleep is the safest thing for him. But it is quite otherwise if he goes directly to a position where his skill and tact, his quickness of eye and steadiness of hand, are to be tried to their utmost. The man whose mind is spurred by alcohol, making him the amusement and entertainment of a gay company, is not the person who can be relied on to drive straight, or to read

the danger signal on the track, or to do just the right thing in the nick of time to save the ship. Most decidedly the mind loses some of its self-control, becomes less quick to see and hear and act, and is less to be relied upon, when the man is a little under the influence of drink.

One symptom of this slight degree of intoxication is the fact that the skin becomes less sensitive to the touch. As the degree becomes greater, the sense of touch and the power of feeling pain become by degrees quite lost, and a man drunk may be burnt or frozen to death without feeling.

The numbness of the skin is not due to the action of alcohol in the skin, but to the numbing or dulling effect upon the brain itself.

Alcohol is not the only agent which produces a benumbing effect upon the brain and nerves. There are a good many medicines which act more or less similarly, and which, in general, are potent poisons, though often of the highest usefulness in the hands of physicians. Of these intoxicant medicines, some are extracted from plants, and others are manufactured chemically.

The frequent and continuous use of liquor very often causes a slight but steadily increasing decay of the higher qualities of the mind. Not only does the intellect suffer, but the sense of duty becomes less active, honor and ambition grow dull, truthfulness and honesty are less keenly observed.

The condition of absolute drunkenness is described elsewhere. The state to which we here allude is that of slight or incomplete intoxication repeated day by day, which is even more injurious to the entire system than an occasional fit of complete drunkenness.

There is a strange and surprising circumstance observed in some men while intoxicated; they act in a manner totally unlike their sound selves, committing crimes which are not, we should say, consistent with their character, and afterwards seeming to be totally unaware of what has occurred. This is a sort of temporary insanity.

Considered as a drug with the power of benumbing the senses and stupefying the brain, alcohol belongs to the class of *narcotics*, which includes ether, chloroform, opium, hashish, belladonna, chloral, and other articles in common use in medicine. As this book does not undertake to teach medicine, it is sufficient to say of these drugs that each has its peculiarities, that each can cause death by poisoning if taken in sufficient quantity, and that the medical value of each should be decided by the physician using them, according to his best judgment.

There are people who, in various ways, have fallen into the wretched habit of using one of these drugs, and "cannot give it up." They will say, "It is like tearing soul and body apart to give it up." One of the worst narcotics and the hardest to abandon is opium; an opium-eater consumes it daily, often constantly increasing the quantity used, and finally uses at a dose enough to kill a dozen men, for the drug loses its first power, and the consumer must take more and more.

Tobacco is also a narcotic; for an account of its effects the reader may refer to Chapter XII. It does not compare with the narcotics named above in its injurious effects.

SYNOPSIS.

The nervous system governs thought, sensation, motion (voluntary acts, circulation, respiration, digestive movements), and secretion. Its duty, expressed in a general way, resembles that of the commander and officers of an army; the other organs and parts of the body being the soldiers. It is the highest part of our system.

The nerve elements are fibres and cells. "A nerve" resembles a thread, and is made of a bundle of fibres supported by a strong sheath. A cell is a small mass of gray matter with a nucleus and one or more branches. With the latter, fibres are connected.

The cerebro-spinal system includes the brain, spinal cord, and nerves proceeding from them. The visceral system belongs to the viscera and the circulation.

The brain fills the entire skull. It is sheathed in a tough membrane. It is soft, grayish, and convoluted. It consists of the

cerebrum, cerebellum, and cerebral ganglia. The first is the largest and uppermost. It is parted into the right and left hemispheres united at the base.

The cortex, a thin surface-layer of the cerebrum, is the organ of the mind. Intelligence is proportional to its development. Numerous and deep convolutions allow a large development of cortex.

The size of the cerebrum proper is another indication of mental power. The whole contents of the skull, however, are commonly weighed together. Man's brain is larger than that of any other animal, with very few exceptions.

The cells of the brain are joined to each other by many fibres. Other fibres pass to the cerebellum, cerebral ganglia, and spinal cord.

The spinal cord contains fibres and cells. Both it and the brain govern motion; but the cord does it without consciousness.

The spinal nerves are large bundles passing right and left from the cord to supply the body.

The ganglionic system is composed of many groups of cells, called ganglia, with nerve-fibres. It is connected with the cerebro-spinal system by nerves. It supplies the viscera and circulation.

The nerves carry messages outward, from the brain and cord to the muscles and glands; they carry messages inward, from the organs of perception and sensation to the cord and brain. A single fibre does not transmit in both directions. A bundle of fibres (a nerve) may contain fibres acting in each direction.

The sense of touch belongs to the skin and mouth. Its organs are situated in the papillæ, and are most numerous where touch is most acute. It is very useful to the blind.

General sensation is that which when heightened becomes pain.

A cut or tied nerve cannot transmit messages of either sort. Pressure on a nerve makes a limb "go to sleep." Cut nerves may in healing recover their function.

Voluntary motion obeys orders from the brain, sent through the anterior spinal nerve-roots. Sensation passes through the posterior roots. This is proved by the experiment of dividing these roots separately.

Paralysis may be caused by disease or injury of the brain or cord, as in apoplexy, tumors, or fractures.

Reflex action occurs independently of the will. It causes many useful movements, often more quickly than we could think to do them. Some such actions are uncontrollable. Many can be performed

without the aid of the brain (experiments with animals). The process includes sensation, carried to the spinal cord and cerebral ganglia; action in the ganglia; transmission of an impulse from ganglia to muscles.

Nervous force is believed to be generated in the nerve-cells. The process of voluntary muscular action includes a series of acts, compared to firing a gun with a string.

Mental action depends upon the cells of the cortex (surface) of the brain-hemispheres. It requires a supply of pure blood in the brain; stoppage of the supply causes fainting. In sleep the circulation of the brain is lessened.

Speech and voluntary action are dependent on the brain, and are properly intellectual functions.

The health of the brain is much dependent on that of the stomach and bowels. Regular habits, exercise, and especially sleep are favorable.

Sleep should be sound and natural; not impaired by tea or coffee. It must be regular. Children of twelve to fourteen years require ten hours; young children more; adults less. Sleep repairs the brain. Waking up tired shows something is wrong — as over-fatigue, late hours, unwholesome food, late meals. The bedroom must be cool and airy.

Pure air improves the action of the mind. The forenoon is often the best time for study; before breakfast is generally a bad time.

Alcohol produces some of its first and most important effects upon the nervous system. It reaches the brain very soon, and quickly increases the amount of blood there. It has also a medicinal and a poisonous action upon the brain. The mental faculties under its influence act differently from their usual way; often irregularly and unsteadily. A benumbing effect is common, which in a higher degree becomes drowsiness or stupor. Sleep is a common result; dead-drunkenness is the extreme. Loss of sensibility of the skin is a temporary effect of this state of the brain.

Continued excess in the use of alcoholic drink is apt to impair both mental and moral faculties. Frequent daily tippling is worse than occasional complete drunkenness. Alcohol may cause temporary insanity, in which the moral faculties are perverted.

Narcotics are substances which stupefy. Many are of such a nature that, when a person acquires a habit of using them, it is almost impossible to break off, and the dose has to be increased from time to time.

SUGGESTED QUESTIONS.

Four of the chief functions of life dependent on the nervous system. The "Seven Senses." Thought. Motion. Secretion. How the system as a whole is governed.

Anatomical elements of the nervous system. Their magnitude. Fibres. A nerve. Cells: form, structure, chemical components, nucleus, branches. A mass of cells. Ganglia. Gray matter. Sheaths of nerves. Two divisions of the nervous system.

Cerebro-spinal system — three divisions. Brain: situation, protection, appearance from outside, convolutions, division into three parts, division right and left. Cerebrum, cerebellum, cerebral ganglia, hemispheres.

Organ of the mind. Cortex: its form, arrangement, situation. Intelligence estimated, — two modes of testing. Size or weight of brain; in animals; absolute, relative. Cuvier.

Connection between cells; between parts of the brain. Functions of cerebellum and cerebral ganglia.

Spinal cord: connection with the brain, components, general functions, function shared with the brain, function not possessed.

Spinal nerves: size, situation.

Cerebral nerves.

Ganglionic (visceral) system. Ganglia. Viscera.

Duty of the nerves. Directions in which messages are transmitted.

Special senses. Touch, where perceived. Organs of touch. Delicacy of touch.

General sensation. Pain. Cutting, tying, pressing a nerve. A limb "asleep." Wounded nerves.

Voluntary motion: originates where? How to interrupt the impulse for motion. Spinal nerve-roots, their functions. Paralysis: causes.

Reflex motion, instances. Its use. Involuntary acts. Experiments on animals.

Nature of nervous force: where produced. Cells of brain. Acts of will. Firing a gun.

Mental action: its organ. Pure blood. Loss of consciousness. Sleep. Dreams. Speech: birds, children, words, disease of brain, monkey's brain. Muscular acts: connection with the intellect.

Disturbance of health of brain: causes. Sleep. Awaking. Causes

of impaired sleep. Habits of sleep. Amounts. Last meal before sleep. Bedrooms: air, temperature. Ventilation of school-room. Time for hard study.

Alcoholic drinks: how they reach the brain. Effects upon the brain: as to circulation, sleep, medicinal effects, activity of mind, conversation. Next morning. Some late effects. Sleep. Steadiness and accuracy. Effects on the skin, and cause. Higher faculties of the mind. Daily slight intoxication. Moral insanity; and criminality. Legal views.

Narcotics. Habits. Opium. Tobacco.

NOTES FOR TEACHERS.

A very fair idea of the appearance of the spinal cord can be obtained by dissecting small fishes; the process is easy, and the brain and cord may be kept together in alcohol. The brain of small birds can easily be removed entire with scissors and knife. If a mammal brain is desired, that of the sheep will serve very well, and costs very little; but the removal of the bones of the skull is so difficult that it may be advisable to let the butcher saw the cranium completely across in any convenient direction before attempting to extract the brain. Decomposition begins very quickly in this organ, and renders it useless for our purpose; the pieces should be well hardened in alcohol, and are then ready for use at any time. Fresh specimens, of course, have a value and beauty of their own.

The expression "special senses" is employed in this chapter in its usual way. Strictly, however, the sense of touch, and that of heat or cold, are also special, as opposed to the general sensation already described.

CHAPTER IX.

THE EYE.

THE eye is a globe or ball, lying in a deep cavity of the skull, called the socket. Its sides and back are protected by the skull; its front is covered by the eyelids. What we see is only a small part of the globe. (See Fig. 58.)

The eyeball does not come into close contact with the bones of the socket, but rests upon a cushion of soft, yielding, fatty

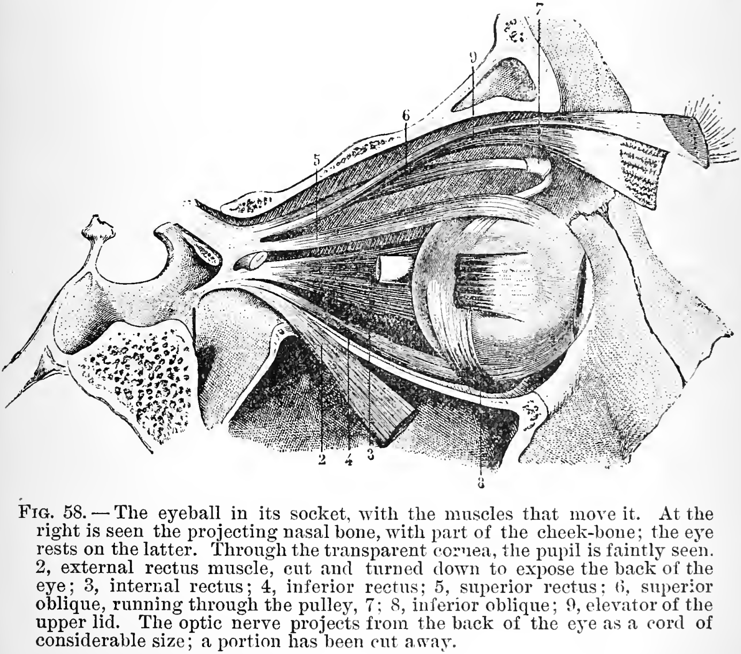


FIG. 58. — The eyeball in its socket, with the muscles that move it. At the right is seen the projecting nasal bone, with part of the cheek-bone; the eye rests on the latter. Through the transparent cornea, the pupil is faintly seen. 2, external rectus muscle, cut and turned down to expose the back of the eye; 3, internal rectus; 4, inferior rectus; 5, superior rectus; 6, superior oblique, running through the pulley, 7; 8, inferior oblique; 9, elevator of the upper lid. The optic nerve projects from the back of the eye as a cord of considerable size; a portion has been cut away.

tissue, which "gives" when the eye receives a blow. If it were not for this arrangement, the eye might easily be ruptured by being struck.

The front of the eye is a smooth surface, over which the lid fits. A little moisture is found between the lids and the globe, which enables the lids to move smoothly and quickly over the surface. In shutting (winking), the lids carry some moisture over the front of the eye and preserve it from drying; they also sweep small particles of dust off. The moisture is chiefly furnished by the mucous membrane which covers the front of the eye and the inside of the lids. On the edge of each lid, near the nose, may be seen a point or dot, which is the opening of a small tube which carries off the moisture that is not needed to the nostril.

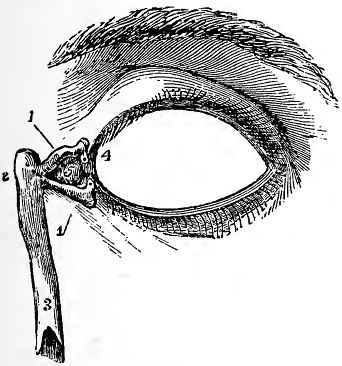


FIG. 59.—Front of the left eyelids, with the lachrymal canals and nasal ducts exposed by dissection. 1, 1, lachrymal canals; 2, lachrymal sac; 3, lower part of nasal duct; 5, fleshy projection at inner corner of eye; between 4 and 5 are two points, showing the openings of the lachrymal canals.

The eyelashes are so placed as to catch dust which might otherwise fall into the eye from above.

The eyeball has several coats. The outer one (*sclerot'ic*) is white and tough; but at the forepart of the globe a circular portion of the sclerotic becomes transparent. This portion is called the *cor'nea*.

The "white of the eye" is that part of the sclerotic which we can see. Behind the cornea, and in full view, is a circular object, the *iris*, colored blue, gray, green, brown, or nearly black. The iris is a flat, round curtain, attached by its edge, just behind the edge of the cornea. Its use is to regulate the amount of light that enters the eye. At its centre is a small round hole, the *pupil*, through which all the light enters the

eye; this hole grows larger in a dim light and smaller in a bright light. This can be seen by holding a hand-glass and facing a window; if one hand is held so as to screen both eyes, and then quickly removed, the pupil will be seen contracting.

The contraction is caused by a little ring of muscle surrounding the pupil, which acts like the orbicularis of the

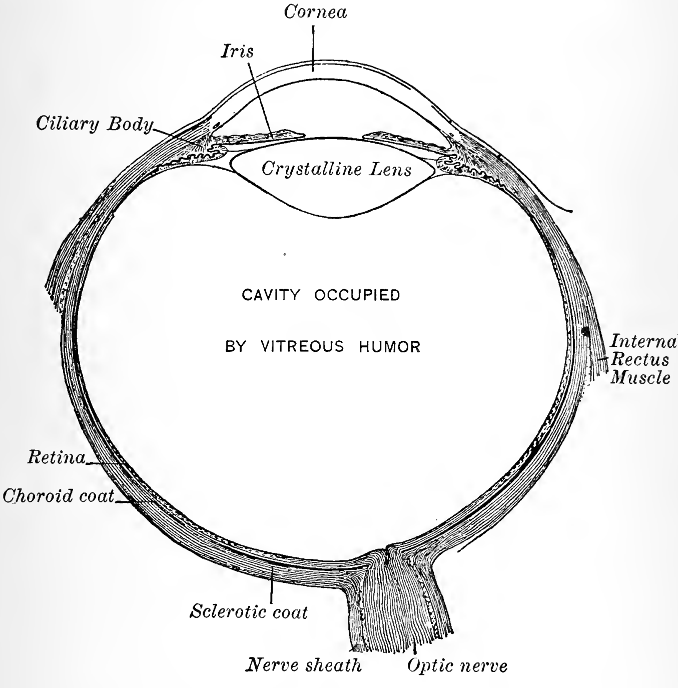


FIG. 60.—Horizontal section through left eyeball.

mouth. Opening, or dilatation, is caused by the action of small fibres which run from the pupil toward the circumference of the iris.

In front of the iris and behind the cornea is a space filled with a fluid nearly the same as water,—the *a'queous hu'mor*.

Behind the iris is a lens, the *crys'talline lens;* and behind that is the main cavity of the eye, surrounded by the walls of the globe, and filled with a transparent material consisting chiefly of water, — the *vit'reous humor.*

The eye may be compared with a little camera obscura, such as is used in photographing: the chief differences are that the interior of the eye-camera is filled with watery material instead of air, and is rounded and not flat. The lens causes the rays of light which come through the pupil to make a picture of what is in front of the eye. In a photographic camera the real picture is seen; in the eye it could be seen (if a convenient opening could be made in the eyeball) upon the back and sides of the cavity, like a painting on the inside of a teacup.

The inner surface of the eye, where the picture is formed, consists of a thin black membrane, over which lies a still thinner layer of nerves and nerve-endings, called the *ret'ina.* The picture is on the retina. The retina *perceives* the colors and forms. Its nerves carry their impressions (as telegraph wires carry their messages) to a central point at the back of the retina, where the whole impression is taken by the *optic nerve* and carried to the brain.

Rays of light, before coming to the retina, must pass through: 1, the cornea; 2, the aqueous humor; 3, the lens; 4, the vitreous humor.

The lens is shaped like a burning-glass; it brings light to a focus as a burning-glass does. If the burning-glass is held too near the paper, or too far away, the spot of light is blurred. So in the human eye; if the retina should happen to be too far back from the lens, or too near it, the picture would be blurred. This, indeed, often happens. Near-sighted eyes are usually longer, when measured from front to rear, than they should be, while far-sighted eyes have the opposite defect. Wearing glasses corrects the difficulty and gives a clear picture. Near-sight exists when a person cannot see at a dis-

tance as well as the average, but does see well near at hand: far-sight is the opposite state.

We have the power of changing the shape of the lens (making it more curved), by a little effort, with a certain small muscle,

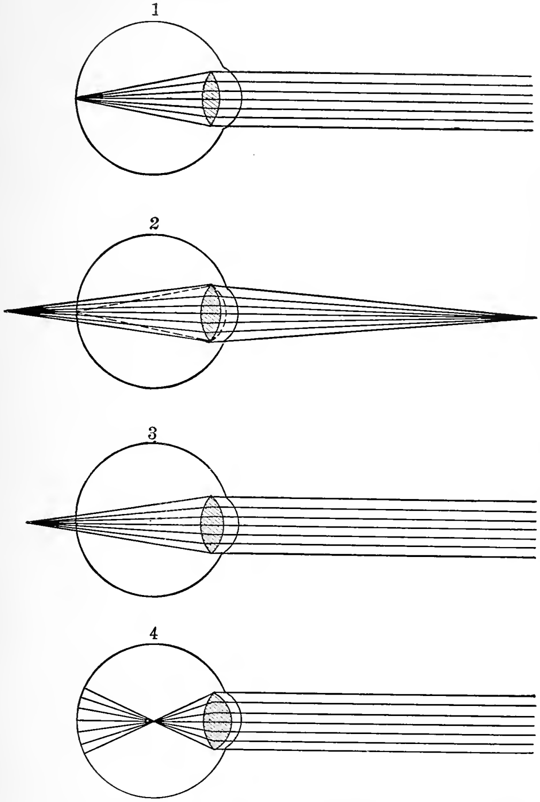


FIG. 61.—Refraction of light in the eye. Diagram 1, normal eye, bringing parallel rays exactly to a focus on the retina; 2, the same, adapted to near rays, the dotted lines showing the change made from 1, making the lens thicker; 3, far-sighted eye, focussing rays *behind* the retina; and 4, near-sighted eye, focussing rays in *front* of the retina.

situated inside of the eyeball. (See Fig. 60.) This act, called *accommodation*, has to be performed when we are looking at

objects that are nearer than usual. If the object is held very near, we have a feeling of "straining to see it": this straining is bad for the eye and tends to make persons near-sighted.

As people grow older they partly lose this power of accommodation. A child can see objects plainly at a distance of three inches without much effort; at fifteen years he cannot see so near; and the change gradually goes on, until, at about forty, many persons are obliged to hold the book two or three feet away in reading. This is called growing old-sighted, and requires glasses of the convex sort.

Muscles of the Eyeball.—Besides the muscles of the iris and of the lens, which are *internal,* there are several external ones, which move the eye in various directions, pointing it to objects we wish to see. Each eyeball has a straight muscle above, one below, and one at each side, besides two which are inserted obliquely and give a twisting motion. The muscles are fastened by one end to the eyeball, by the other to the socket. In moving the eye we use them unconsciously, though not involuntarily. If a muscle on one side of the eye is weak, the one on the opposite side overbalances or overpowers it, and gives the eye a turn or twist away from the straight line. This is one cause of squinting. (See Fig. 58.)

NEAR-SIGHT.

Among savage nations, where no books are used, almost every one has good sight, and near-sight is hardly known. The use of books and writing is a great blessing to man, but has certainly done harm to many individuals by weakening their vision. The greatest amount of near-sight is found among the Germans, who are the greatest students, and whose children study considerably more than ours do.

Many inherit near-sight from their parents. In others it begins while they are at school. In all, it is extremely likely to go on increasing unless great precautions are taken. Children at study, or while writing, seem to have a natural wish

to get their eyes close to the book, — the very worst thing for near-sight.

Near-sighted eyes may be healthy in other respects, but (in not a few) there is a tendency to grow worse rapidly, until finally the sight is nearly lost, and spectacles are of very little more use: almost complete blindness may be the result of this state.

A child that is at all near-sighted ought to be most careful to observe these rules. In particular, he should have a good light; keep the book as far away from the eyes as convenient; sit up, and not stoop over the work; do no study of fine maps or close small print; and execute no fine work with pen or needle.

FAR-SIGHT.

Far-sight (technically called over-sight, or hyperopia) is not an uncommon affection of the eye in childhood; but it is only within recent years that much attention has been paid to it. Those suffering from it cannot fix the eyes on near objects, as in reading, with the same ease that others can. The effort to read produces pain in the eye or head, and sometimes other troubles, which may become so serious a matter as to force the child to give up school. It is most important, therefore, to know that these children possess eyes shaped like the eyes of old persons, and that their trouble can be relieved by wearing "old-sighted" glasses.

To avoid dangerous mistakes, medical advice should be taken before choosing glasses for near-sight, far-sight, or any other defect of vision.

HYGIENE.

There are very few professions or trades which do not require good eyesight, though there are great differences. Well-educated people, in particular, require to make great use of their eyes in their work. Children should begin when young to obey the rules which will save them from hurting their eyesight.

The eyes are "tried" or tired in various ways. The rules

which are here given are intended to apply to reading, writing, drawing, and other school work, besides sewing and embroidering. To save repetition, the word "read" is used in the rules to signify any or all of these operations.

RULES FOR PRESERVING GOOD SIGHT.

1. Do not read at or after sunset by natural light.
2. Reading out of doors is commonly trying to the eyes; there is too much light.
3. Do not read with sunlight falling on the book.
4. Do not read with a window, or a light, directly in front of you, unless you have a screen to protect the eyes.
5. Protect the eyes with blue or gray glasses when the sunlight on the snow is dazzling; many require them at the seashore also.
6. Never read by a flickering light.
7. Use a screen to keep off the heat of the burner if near your head. The head must not be hot while reading.
8. Use light-colored paper and strong black ink or pencil for writing.
9. Prefer daylight for reading. It is well for students to save an hour of daylight at the beginning of the day by having an early breakfast.
10. Reading before breakfast, especially by artificial light, is bad for the eyes of most persons. The body is weakest at that time, and the eyes are weak when the body is so.
11. Do little eye work when tired or sleepy.
12. Stop and rest when the eyes feel tired or sore. Rest often, in any case.
13. Do not undertake close, hard study soon after dinner.
14. Have the clothing loose, especially at the neck, and sit erect while reading. Never read lying down.
15. From fourteen to eighteen inches is a good distance for the book or paper.
16. After some fevers (measles, scarlatina, diphtheria) the eyes may be weak for a long time, and in that case the scholar must be almost wholly kept from using his eyes.

If a small object gets into the eye, it should first be looked for on the front of the eyeball, and when found, gently wiped

off with the corner of a handkerchief. If not seen there, the upper lid may be rolled over and the object sought on the reversed inside. This operation is performed with a lead-pencil, laid flat on the upper part of the lid; the lashes are taken hold of, and the lid pulled back over the pencil. If necessary, search the lower lid in like manner.

The wind, blowing long and violently upon the eye, may cause painful inflammation of the front part. Dust, sand, and excessive sunlight may do the same.

As too much sound can make the ear deaf, so too much light can make the eye blind. This may take place instantaneously when looking at the sun.

Blindness, complete or partial, can be caused by anything which obstructs the passage of light, or which injures the retina or nerve or brain. The following are some of the chief causes: —

1. The cornea may lose its transparency, or may become perforated, in inflammation. There is a disease called pu′rulent ophthal′mia, which attacks the front part of the eye and produces blindness. It is very easily caught by one child from another; it may be taken, for instance, by a healthy child, in wiping its face on a towel used by a diseased child. It is common among children who live together, great numbers sleeping crowded in one room, and who have poor food and poor air. Diphtheria or small-pox may cause this blindness.

2. Weakly, dirty, scrofulous, ill-fed children often have sore eyes, with red lids and a blurring of the front of the cornea. Great cleanliness is required in the care of such eyes.

3. Any wound or disease that injures the optic nerve may cut off the sight; the eye may form a clear image, but the image will not be carried to the brain, and so the mind will not know of it.

4. The lens grows opaque in the disease called cataract, which is very rare in childhood.

SYNOPSIS.

The eye or eyeball is protected by the socket and the lids; it rests on a cushion of soft tissue. The mucous membrane of the front of the eye secretes moisture, which facilitates the movements of the lids; superfluous moisture is carried off into the nostril. The eyelashes catch dust.

The outer coat of the eye, the sclerotica, is tough. A part of the front is transparent, and is called the cornea. The white belongs to the sclerotica. The iris, or colored part, is a curtain behind the cornea, with an aperture, the pupil, varying in different lights; the change is due to the muscles composing the iris.

The aqueous humor is in front of the iris, the crystalline lens just behind the iris, and the vitreous humor fills the main part of the eyeball.

The eye is a camera, with spherical interior. The rays of light form a picture on the retina, or layer of nervous substance, at the back of the eye. The retina receives an impression of light; the optic nerve carries it to the brain, where the impression is perceived.

The lens concentrates light like a burning-glass. It requires to be placed at a certain "focal distance" from the retina. An eyeball that is too long (in near sight) or too short (in far sight) from front to rear disturbs this relation and gives a blurred image. We have some power to change the shape of the lens; this act may cause a sense of straining the eye; this power is lost by degrees as life advances.

The eye is moved in various directions by several small muscles. Affections of these muscles may cause squinting.

Near-sight is peculiar to civilized nations, especially those where a great deal of studying is done. It is often inherited. It may begin at school. It is very likely to increase. In some cases it causes nearly total loss of sight. Strain of the eyes in fine work, with poor light, and holding the eyes close, are causes.

Far-sight in children makes it difficult to apply the eyes to school work without suffering. It requires the use of glasses.

(The "rules" need not be repeated.)

Small objects can be taken out of the eye with a little skill. Inflammation may be caused by wind, dust, excessive light.

Blindness may be caused by purulent ophthalmia, a disease of neglected children, in crowded rooms, with poor food; also by small-

pox or diphtheria. Scrofulous and ill-kept children often have chronic sore eyes, with weakened sight. Disease of the optic nerve, or of the lens, may cause blindness.

SUGGESTED QUESTIONS.

Socket of eye. Protection of the eyeball. Blows. Eyelids: motion; moisture. Eyelashes.

Coats of eye. Sclerotic. Cornea. White. Iris. Pupil; movements. Aqueous humor. Lens. Vitreous humor. Camera; shape. Retina. Focussing. Transference of visual impression. The path of a ray of light. Defects in focussing. Deviations from normal form of lens. Near-sight; far-sight. Accommodation. Straining to see near objects. Change with advance in years. Old-sight.

External muscles. Squinting.

Near-sight: where prevalent; causes. Tendency of near-sight; results in extreme cases. Cautions for those near-sighted.

Far-sight: in childhood; symptoms; consequences; means of relief. (Rules.)

Way to remove objects from the eye. Causes of inflammation. Light striking the eye. Causes of blindness. Purulent ophthalmia: symptoms; causes. Other diseases causing blindness. Chronic sore eyes. Injury of optic nerve. Cataract.

NOTES FOR TEACHERS.

The eye of most quadrupeds is rather too well protected by the skull to be easily studied *in situ*. The butcher can readily furnish a supply, taken fresh from large animals. The lens can easily be removed, and made to magnify print. The toughness of the outer coat and the abundant black pigment of the interior of the eye will be noticed.

Freezing an animal's eye (with a mixture of ice and salt) enables us to cut it in two, giving instructive views of the interior. A fish's eye, with its nearly globular lens, may be compared with the above.

CHAPTER X.

THE EAR.

DESCRIPTION.

THAT which we commonly call the ear, the part which is seen, is scientifically called the *concha*, from its resemblance to a sea-shell (Latin, *concha*).

The passage, an inch and a quarter in length, leading to the drum, is called the *mea'tus*.[1] It is directed forward, and the drum can seldom be seen without the aid of an instrument. It is lined with skin; at its outer part it has little glands, which secrete the ear-wax or *ceru'men*.

The end of the meatus is closed by a sort of skin or membrane, tightly stretched across like the head of a drum. It is commonly called the *drum of the ear*, though *drum-head* would be a better term.[2] Behind this is a small cavity (which corresponds to where the drum should be), called the *tympan'ic cavity*, or *middle ear*.

In the middle ear there is a set of *small bones* of peculiar shape, resembling a hammer, an anvil, and a stirrup. They are joined together in a string, which reaches across the cavity of the middle ear, the hammer at one side touching the drum, and the stirrup at the other resting on an opening in the side of the cavity which leads to another region, called the *inner ear* or *labyrinth*. This cavity is composed of a curious set of winding channels, tunnelled out of the middle of the

[1] Latin, *meatus auditorius externus*, outer auditory passage.

[2] *Membra'na tym'pani* (drum-head) is its scientific name.

hard bone of the skull. One of the channels is spiral, like a snail-shell; the others are shaped like loops. These curious passages are occupied by the spreading, fringe-like terminations of the nerve of hearing.

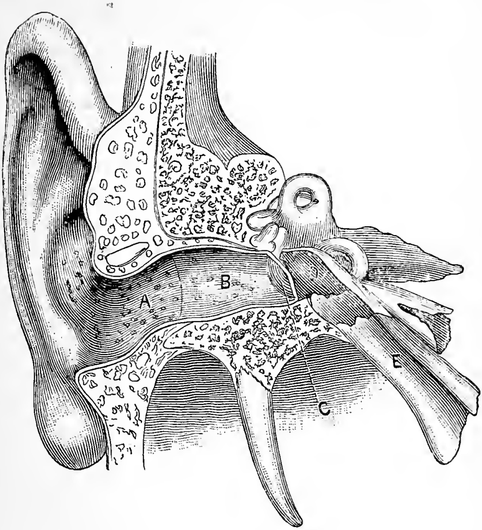


Fig. 62. — The ear, cut across vertically. *A*, meatus, outer part; *B*, inner part; *C*, drum, divided near the middle; *D*, middle ear; *E*, Eustachian tube. The labyrinth is above the letter *D*. The small bones are not represented.

From the middle ear there is a passage, called the *Eustachian tube*, which leads forward and downward and ends in the upper part of the throat. (See Fig. 52, number 10.)

Each ear is entirely independent of the other.

FUNCTIONS.

The ear is, of course, the organ of hearing. The sound comes through the air in waves, which are not seen, but only heard. Such waves are more like a thrill or a trembling than the waves we see in water. By placing the hand on almost any musical instrument while it is played upon, especially if

it has a deep strong tone, we can *feel* the thrill of the sound-waves. By listening at one end of a log while another person whispers at the other, we can observe how sound is conveyed by a piece of solid wood.

The part which hears is the inner ear, where the nerves are. All the other parts serve to catch the vibrations and convey them to that part. The concha or external ear is not of very great importance, but it is of some use in collecting the sound-waves and throwing them towards the meatus, as an ear-trumpet does. The drum catches the sounds, and vibrates in the most delicate way at every wave. The small bones pass the vibrations of the drum on to the labyrinth, where they strike against the fine fringes of nerve. Here the sound for the first time comes in contact with nerve, and stimulates it. This stimulation is carried by a cord of nerve-fibres (auditory nerve) to the brain; whereupon, we become conscious of sound.

HYGIENE.

Dirt and dust seldom penetrate to the farther end of the meatus; they are mostly caught on the sticky sides of the passage near the outlet. A very little wiping out will suffice for neatness. A daily washing of the outer parts (the concha) on all sides, with good soap and water, is wholesome; but when we reach the passage, we ought to go in no deeper than we can most easily reach with the tip of the little finger covered with a damp cloth. Ear-picks are dangerous, as they may reach the drum and injure it, thus causing deafness.

The wax usually tends to move outward, and can be removed when it comes in sight. In some persons it collects in a lump near the drum, and stops the passage, causing deafness. The remedy is for a physician to syringe with warm water until the lump is softened and comes away, when hearing returns at once. The most experienced physicians will hardly ever use any other instrument to get away things from the ear, for fear of doing damage by poking among the delicate structures.

Insects dislike the ear-wax; but if one gets in, a drop or two of sweet oil will dislodge him.

A violent box on the ear has been known to burst the drum and cause deafness. It is not a safe place to inflict punishment.

Persons who bathe much at the seaside are exposed to deafness from two causes. First, the surf may strike directly into the ear and give a blow to the drum; there may be sand in the surf, which will make matters worse. Then, secondly, people often stay in too long and get chilled, and the chill is very apt to "strike to" the ear, where it causes inflammation. There is a notion that people cannot take cold by the seashore; but slight colds which affect the middle ear are often caught.

Colds in the throat (sore throat) are very liable to affect the middle ear, through the direct passage (the Eustachian tube) from the throat to each ear, up which inflammation spreads. There is often a bad sore throat in scarlet-fever, and this is one of the commonest causes of deafness in children.

Children are sometimes thought to be stupid or careless, when in reality they are only deaf. Some deaf ones are usually found in every school-room. Some catch cold easily, and colds settle easily in their ears; every fresh cold of this sort is liable to make them a little deafer; such scholars must not sit in draughts of air. It is far easier to prevent than to cure deafness; the curing takes a long, tedious while. As preventives, wear flannel, avoid colds, avoid bathing in surf, or diving, avoid violent winds, or draughts in rooms, be much out of doors, and grow strong.

Very loud noises, as the firing of cannon, may cause deafness. Boiler-makers, who have to go inside of a boiler while workmen are hammering on the outside, are often deaf.

SYNOPSIS.

The outer ear is called the concha. The passage (meatus) secretes wax (cerumen), and leads to the drum (membrana tympani). Behind the latter is a small cavity, the middle ear, containing three little

bones, which conduct sound from the drum to the inner ear (labyrinth), where the terminations of the auditory nerve are arranged. The Eustachian tube leads from the middle ear to the throat.

Sound is conducted by vibration of the air, or of solid bodies. All the outer parts of the ear are formed to receive and conduct the vibrations to the inner ear, where the nerve is found which carries the sensation to the brain.

It is extremely improper to poke or push articles into the ear, and may be dangerous to hearing. Syringing is the best way of extracting things from the passage. Wax is thus removed. Blows on the ear may break the drum. Sea-bathing may produce a chill, or the surf may directly injure the drum; deafness is occasionally thus caused. Colds in the throat, or the sore throat of scarlatina, may spread up the Eustachian tube and cause deafness. School children often suffer from this complaint. Loud noises may cause it.

SUGGESTED QUESTIONS.

Concha. Meatus. Drum. Membrana tympani. Middle ear. Bones. Labyrinth. Nerve of hearing. Eustachian tube. Vibration. Conveyance of sound. Conveyance of vibration. Conveyance of sensation.

Dirt in the ear. Cleansing. Wax. Removal of substances. Insects. Blows. Bathing. Deafness: some causes. Colds. Sore throat. Scarlatina. Deafness in school children. Prevention. Noise.

CHAPTER XI.

THE TEETH.

A FULL set of teeth, in a grown person, numbers thirty-two. For each one in the upper jaw there is a similar one in the lower. Beginning at the middle line, in either jaw, we can count on each side two cutting-teeth (inci'sors), one eye-tooth

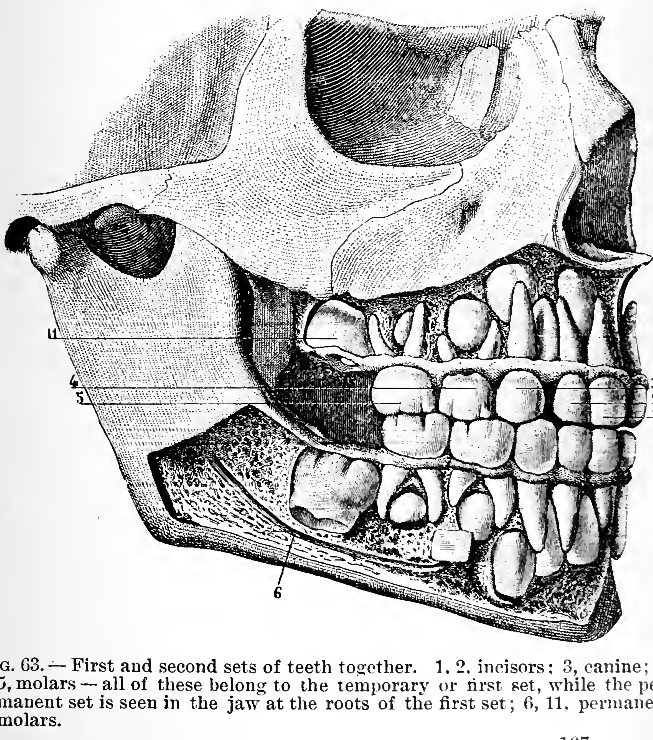


FIG. 63. — First and second sets of teeth together. 1, 2, incisors; 3, canine; 4, 5, molars — all of these belong to the temporary or first set, while the permanent set is seen in the jaw at the roots of the first set; 6, 11, permanent molars.

(canine), two small grinders (bicuspids), and three larger grinders (molars). The last molar is not commonly seen until the age of eighteen or twenty; it is called the wisdom-tooth (very inappropriately), and may not appear till much later in life; it is apt to decay sooner than the others.

Children get their first set of teeth (the "milk teeth") at various periods, beginning from the fourth to the sixth month of life. This set comprises twenty teeth, viz.: eight incisors or cutting-teeth, four canines or eye-teeth, eight bicuspids, or grinders, with two roots.

At the age of five or six years these teeth begin to drop out, and are replaced by the second or permanent set. The jaw-bones, at this age, present the appearance shown in Fig. 63, where both sets are seen to be present at once. The second set grows under the roots of the first set; as they grow, they make the roots gradually disappear, until, by the time the new tooth is ready to push through the gum, the root of the old one is almost wholly gone, and the tooth hangs loosely to the gums.

In many children the teeth of the second set grow out irregularly. Some are blocked or pushed aside by the old teeth, which do not drop out soon enough. Some grow in towards the mouth or out against the lips. Teeth may be too large for the jaw; they then crowd each other, making the line of teeth uneven. Children's mouths should be examined at this age by the dentist, who may take measures to make room for the teeth to grow, and to form them into a regular and handsome line.

The character of the food eaten by an animal can be known from the form of his teeth. The cutting teeth, with edges like chisels, are much used by horses, cattle, deer, sheep, and others which crop the grass; they are large and strong in such animals, and still more so in those which gnaw,[1]—rats and mice, squirrels, beavers, etc. The canines[2] are found large

[1] Gnawing animals are called *rodents*, from the Latin *rodens*, gnawing.
[2] From Latin *canis*, a dog.

and long in many beasts, as cats, lions and tigers, dogs and wolves, which require such teeth in catching and tearing their prey. Such animals have much smaller front teeth, and their back teeth are not used for grinding, but for cutting up food. Any one may notice the sharp edges of the back teeth of a cat or dog, and how they fit together like the blades of scissors. Such animals do not grind up their food, but quickly chop it up and swallow it.

Grass-eating animals are called *graminiv'ora*, and grain-eaters, *graniv'ora*. For grinding their food they possess large, strong, flat back teeth; the cow and horse are good examples.

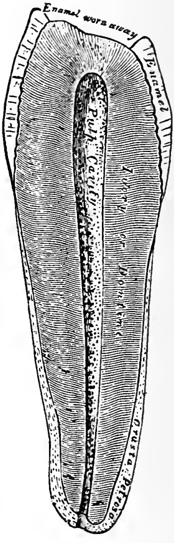


Fig. 64. — Vertical section of a bicuspid tooth, magnified.

Man possesses all three classes of teeth, and they are more nearly equal in size than those of the animals mentioned. He is therefore fitted for eating a great variety of food, both animal and vegetable.

The main part of the substance of a tooth is composed of a material called *dentine,* which resembles bone. The dentine is protected by a rather thin layer of a much harder substance, the *enamel*, which covers all the parts of a tooth that can be seen; the roots are covered with still another substance, the *cementum* (or *crusta petrosa*). In the middle of every tooth is a cavity, the *pulp-cavity,* filled with soft tissue, and containing nerves and blood-vessels. This cavity extends into the roots; at the tip of each root it ends in a small hole, through which the blood-vessels and nerves enter the tooth.

The *crown* of a tooth is the part which is visible, and is covered with enamel. The *neck* is the part just above the gum. The *roots* are firmly wedged into the jaws, somewhat as a nail is in wood.

The enamel gets worn off from the crown of the tooth, at the top, generally by the twentieth or thirtieth year of age. The dentine then comes into use, and commonly answers the purpose as well as the enamel, though it is less durable. It is, however, liable to decay, and small holes or cavities are often formed in it. The dentine, in some persons, is sensitive to pain, and the cavities in it are apt to be tender and cause pain when a person eats. The nearer the cavity gets to the pulp of the tooth, the more sensitive it becomes; and when the pulp-cavity is reached the pain is severe, since the very nerves themselves are laid bare.

Filling a tooth consists in clearing out the rotting dentine around the cavity, and then inserting some preparation which will perfectly fill and stop up the cavity.

The advantage of filling a cavity is, that the decay is stopped at that point. It is always desirable to do this; even young children ought to have their teeth kept as sound as possible, so as not to lose any until Nature is ready to furnish the second set. If the first ones drop out too soon, it may happen that the second ones, when they come, will find the jaw too small for them, and then they crowd each other, producing an ugly appearance, or some may even have to be pulled out to give room for the rest.

The jaw changes a good deal in its shape and proportions at different periods of life, becoming stronger and affording more room for teeth as a person grows from infancy to adult life. (See Fig. 65.) In old age, or "second childhood," after the teeth are gone, the parts about the sockets shrink, and the bone becomes more like that of an infant.

Few people are entirely free from caries of the teeth. Even the savage Indians of our country are subject to it, and suffer from toothache. Decayed teeth are a cause of foul breath. They sometimes produce the most horrible neuralgia of the face. And there is this further disadvantage in losing teeth, that a person cannot chew so well, and neither enjoys his food, nor digests it so well.

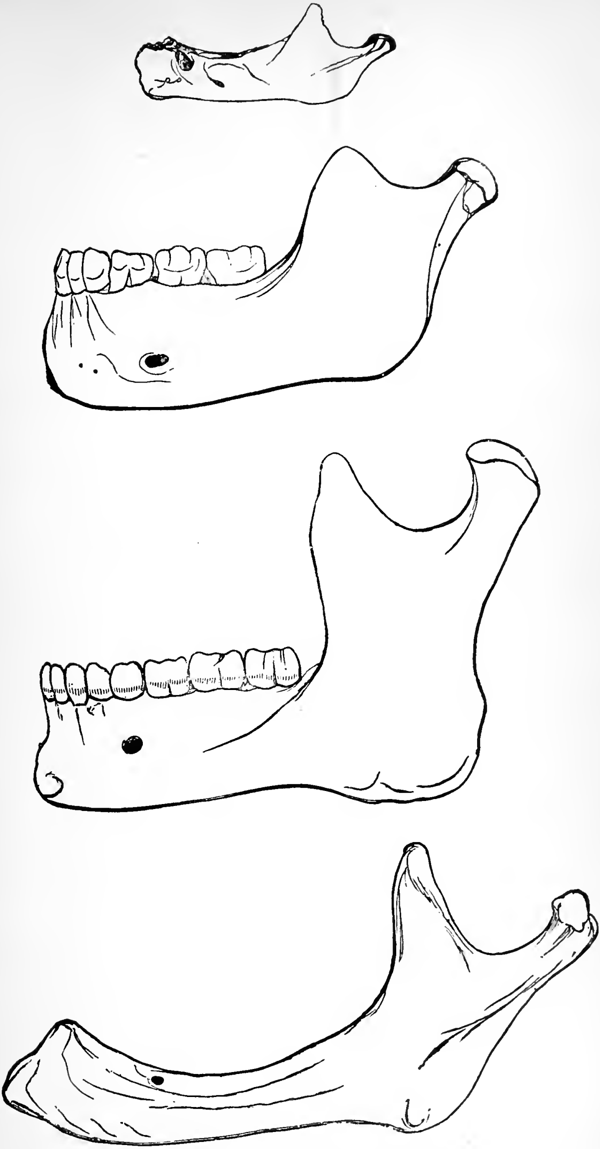


FIG. 65.—Side view of the lower jaw at different periods of life. 1, at birth; 2, at age of 14; 3, in the adult; 4, in old age.

Some persons' teeth are so poor that they seem to decay in spite of the best care, but cleanliness will do a great deal in preventing caries. The teeth after eating remain coated with food, which is liable to become decomposed, and to produce acids that eat into the teeth. The proper time, therefore, for cleaning the teeth, is after meals. A toothpick is needed to remove bits from between the teeth, and then a brush, dipped in water and lightly rubbed on soap, is to be used both inside and outside. Of course, the purest white soap is required. Pumice stone powder is bad, as it wears away the teeth. A dry cloth and a thread may be required by some, to perform more perfectly the office of toothbrush and toothpick.

Some persons' mouths are always sour. This is an unhealthy state, partly due to a bad stomach, caused by eating unwholesome food. A reasonable amount of sweet food at meals is proper, but a constant nibbling of candy between meals is sure to injure the stomach and teeth. The sugar is not all swallowed, either; some of it adheres around and between the teeth, and very soon ferments, turning to an acid which attacks and rots the teeth.

There is in soap an alkali (soda) which corrects or "neutralizes" this acid; hence soap and soda are useful for toothwashes.

Particles of food adhering to the teeth or sticking in crevices will decay quickly and produce foul breath, with injury to the teeth. It is very important to clean the teeth so as to remove all the particles of food.

A toothpick of quill or wood should be used after each meal. Even better than a toothpick is a piece of waxed thread, a waxed floss-silk, or a piece of a small rubber-ring. (Toothpicks should not be used in company or carried about in the mouth.)

The toothbrush is more effective when rubbed up and down instead of across. Soap is useful with the brush. As a toothpowder, fine precipitated powder of chalk is best; it not only helps to remove substances from the teeth, but being an antiacid it corrects the sourness of the mouth.

SYNOPSIS.

The teeth in the upper and lower jaws correspond; the right and left sides also correspond. Reckoned from the middle, the adult has 8 incisors, 4 canines, 8 bicuspids, and 12 molars = 32. The wisdom-teeth come latest, and often decay early. The first set comprises 8 incisors, 4 canines, 8 bicuspids, which are replaced by permanent teeth after the age of five. The new ones grow under the roots of the old, which gradually waste away to give room for the new growth. If this process goes on irregularly, the teeth may grow in the wrong direction. They may be too large for the jaw; or the jaw may be too small for the usual size of tooth. The dentist should examine children's jaws to prevent the deformity caused by these circumstances.

The front teeth are strong in the herbivorous animals, still more so in the rodents. The canines are powerful in the carnivora, as lions and wolves. The back teeth are large and flat in the herbivora, sharp like scissors in the carnivora. In man, all are developed in nearly equal proportion, to suit his mixed diet.

The substance of a tooth is dentine. The roots are covered with cementum, the crown with enamel. The central pulp-cavity contains blood-vessels and nerves, and extends to the end of the root. When the enamel is worn off from a part, decay is more likely to occur. Cavities in the dentine are painful in proportion as they are deep; filling relieves pain and stops decay; the decayed material is removed before filling. Filling cavities in the first set is to be recommended; if they drop out prematurely the jaw fails to get full growth.

Caries occurs among all nations. It causes foul breath, toothache, neuralgia, and dyspepsia. Cleanliness is the best preventive, though not always effectual; it comprises cleansing with brush and soap. cloth, thread, and toothpick; carefulness in diet (no sweets allowed out of meals); and the use of antacids when needed.

SUGGESTED QUESTIONS.

Number of teeth of each sort in adult set; in first set. Wisdom-teeth. Ages at which teeth appear. Process of exchange of first for second set. Irregularities in the process; consequences, remedies. Form and relative size of the different classes of teeth in different

families of animals; uses of such special forms; in man. Dentine, enamel, cementum, pulp-cavity, crown, root, neck, nerves, blood-vessels. Decay, first step; sensitiveness; filling — the process, its advantages, and the age for doing it. Premature loss of first teeth; effects. Savages. Effects of caries. Time for cleansing the teeth. Instruments to be used. Powders or washes. Particles of food. Sweet food, or candy. Antacids.

NOTES FOR TEACHERS.

The study of the teeth of animals can be made extremely interesting. The skull of one of the carnivora (dog, cat), one of the herbivora (sheep, goat), and one of the rodents (rat, squirrel), can be prepared for use by removing the soft parts with a knife, and soaking the bone in water five or six weeks until the remaining bits of tissue can easily be removed by cleaning. In winter, keep in a warm place while macerating. An adult animal should be chosen. The comparison of these specimens with one another and with the human skull cannot fail to be interesting.

In Professor Bowditch's little manual ("Hints for Teachers in Physiology") the subject of the teeth is treated at some length and very practically.

CHAPTER XII.

STIMULANTS AND NARCOTICS.

ALCOHOL AND ALCOHOLIC BEVERAGES.

ALCOHOL is a clear liquid looking like water; it burns very easily, and gives a hot flame.

It is made from various substances containing sugar or starch, by fermentation and distillation.

The juice of grapes contains much sugar. If allowed to stand, the juice will, after a while, become full of small bubbles of carbonic acid gas (like soda water), and its taste will change; these are signs that the sugar is turning to alcohol. When fermentation is over, the liquid is wine, and contains alcohol in varying proportions (from four to fourteen per cent or thereabouts), according to the amount of sugar. Cider is made in the same way from apple juice, but the sugar is incompletely changed, and the percentage of alcohol is small — about five parts in one hundred. This process is *fermentation.* Beer is a fermented drink made from grain.

Grain, potatoes, or similar food-substances, when mashed with water, will ferment in like manner. After fermentation is over, the liquid is placed in metal boilers with long tubes attached, called stills, and heated: the steam that comes out consists of the vapors of water and alcohol mixed, and both are condensed by cooling in the pipe, where they form drops of fluid. This process of heating and condensing is *distillation,* and the product is *distilled spirit,* consisting of alcohol mixed with water, and various other substances in very small quan-

tities. In the common forms of spirit (rum, brandy, whiskey, gin), about one-half is alcohol and one-half water.

Pure alcohol is rarely seen; that which is used for burning in lamps contains some water. It has various useful properties in the *arts* and *medicine*, owing to its power of dissolving many substances (gums, varnishes, certain drugs) which water will not dissolve. In science, it is useful for preserving specimens in natural history, as fishes and snakes.

When used as a *beverage*, or drink, alcohol is not taken unmixed except by savages: its taste is altogether too hot and disagreeable for civilized man. The drinks which contain it vary in strength (as above noted) from about one-twentieth alcohol to about one-half. Their effects are not exactly alike; but they all possess, in proportion to their strength in alcohol, a certain well-known, poisonous effect, which is called *intoxication*,[1] or drunkenness. This effect consists (in brief) of a weakening of the powers of the mind and of the muscles.

A sober person, sitting with others who are drinking, notices that they seem in gay spirits. Presently they begin to say foolish things, and laugh at them as if they were witty. They are apt to say many things which they afterward wish they had not said. The Latin proverb "In vino veritas" (there is truth in wine) means that a person who has a secret to keep is apt to let it out if he is drinking. Many persons have a bad side to their character, which they are able to control when sober, but when drunk they seem not to care about right or wrong. Some use vile language, some become quarrelsome, or wildly furious, and fight with their best friends, or beat their wives and children. Men who are good and peaceable while sober may be changed into wild savages by drink.

One other change is that the hand is less steady, and the legs less firm; the gait becomes staggering and tipsy; and at the end one is quite helpless, and lies perfectly stupid on the ground. While in this state of "dead-drunkenness," which

[1] From a Greek word meaning "poison."

resembles a fit of apoplexy, the stomach often casts up what has been eaten and drunk. In this condition the heart keeps on beating and the lungs breathing; but cases have occurred in which they have come to a stop under the influence of the alcohol, and death has ensued.

After a fit of drinking, a man's stomach is in a very bad condition; he cannot eat, he feels sick all over, his head aches, he is miserable. At such times the stomach, if seen, would appear very red, almost inflamed.

With most poisons, a person usually feels sick or distressed or in pain. With alcohol, the first feeling is usually pleasant, and *that* is noticed; but the foolishness, the weakness, the neglect of duty, the loss of control over the muscles, are not noticed, but begin gradually and unperceived. Many persons are "not quite themselves" a good deal of the time, from drinking, but are not aware that they ever are "affected" at all, though their friends see it clearly.

One of the surest ways of forgetting how much one has taken is to drink in company, or because another invites and pays. It is as childish to drink when you are asked as it would be to eat because you are asked, without regard to hunger.

It is a proof of the bad effect of alcohol on the mind, that in situations where great care is required — as among railway conductors and engineers — no drinking man is employed. A very little drink may take away the fineness of the sight or hearing, or make a man slow or careless, or his hand unsteady; and the worst is, the man does not know it.

People differ much in their power to resist these poisonous effects of spirituous liquor and beer. Some have such "strong heads" that they seem able to take unlimited quantities.

Many consume a good deal, but do not become drunk; they drink a little at a time, and are all the time under the influence of liquor to a slight extent. It is probable that this practice injures the constitution more than occasional fits of intoxication; it breaks down the health in a slow way, unperceived by the sufferer at first.

Thus, in various ways, we find that there may be danger, even when a person seems to be moderate in his habit of drinking. It is not always easy for a person to decide whether he is moderate; his neighbors may see more clearly than he does, and may notice things about him which he cannot see. Or, a man may be so accustomed to the use of alcoholic drinks, that even large quantities may never make him positively intoxicated. To tell the truth, both these classes of men are really in some degree drunkards. Neither of these classes is capable of resisting the effects of long-continued drenchings with the deleterious fluid; sooner or later, the powerful laborer, no less than the sedentary clerk, succumbs.

It seems also to be a fact that many persons have a tendency to increase gradually the amount taken. This is one of the worst dangers attendant on the use of alcoholic drinks.

In prescribing stimulants, a careful physician will bear in mind the possibility that his patient may continue their use when they are no longer necessary; for the taste is easily acquired, and the ill effects are likely to be overlooked.

Americans are generally affected more by a given quantity of drink than the inhabitants of Northern Europe are by the same amount. It seems to be more injurious to us than to them. It is thought that the climate is the cause of this difference.

The habits of life in Europe are in many ways different from ours. Some of the nations use wine as commonly as we use water, as in Italy, Spain, and Greece. These nations have small appetites for food, and consume much less at a meal than we do. In Germany and parts of France beer is taken regularly as a drink by almost everybody. A very large number of the working classes, in all these countries, really cannot get enough to eat; an American laborer would look with pity on their regular diet, consisting chiefly of bread, cheese, cabbage, and a little sausage, with fresh meat perhaps once a week, but with nothing so expensive as butter. In some regions the peasants mix the ground bark of trees with their bread, for

want of sufficient flour. A little cheap beer or wine goes a great way with such people in making their wretched food palatable. They regard it as we do tea — as a part of their regular diet. Nowhere in our country do laborers have that excuse which these people have for using alcoholic drink.

At the same time, drunkenness does a great deal of harm all over Northern Europe and in Great Britain. It may be called a national vice in those countries. If they can bear more than we can, they nevertheless suffer from taking too much. And this has always been known to be the danger, for drunkenness with wine is mentioned as a very evil thing by Solomon, who lived nearly three thousand years ago.

The effects already described are produced by all kinds of alcoholic drinks. But there is a difference in the quality of liquors, due to the presence of certain flavoring matters, which are often really medicines, unfit to be used by well persons. The difference in the taste of rum, gin, and whiskey is due to such flavoring. Wine, beer, cider, each contain peculiar substances. Beer has a special stupefying ingredient (lupulin) which comes from the hops used in making it. Cider in excess will make people drunk.

Strong drink is a cause of insanity; about ten per cent of the cases in asylums being due to this cause.

A person furiously drunk is as truly insane, for the time, as the worst maniac.

Persons who have kept up the habit of drinking much are apt to have an attack of *mania a potu* ("drink-madness"), otherwise called delirium tremens. In this disease the mind is wild, full of fear and of false imaginations; the patient thinks he sees all kinds of horrid creeping things, snakes and rats, around the room and on the bed; he tries to get away, and would jump from the window if not prevented. Death is not uncommon in this complaint.

Another form of insanity is met with in many persons who seem to be well most of the time. Once in a month or two, a very strong desire to drink comes over them, and it seems

impossible for them to avoid drinking unless they are locked up in some asylum; they get drunk and stay so for many days, after which they recover and go about their business, and are sober until the attack seizes them again.

It has been much questioned whether alcohol can be considered as a food. The point is not discussed in the present work. At all events, it appears to have the curious power of taking the place of food to some extent.

There are other drugs which have the same power.

The drug *coca* is used by South American Indians on very long marches, and in severe work in the mines, and it keeps up their strength for days while they have hardly any food; but coca, if taken too long and too freely, makes a man a wretched, broken-down invalid. How, when, and in what quantities, alcoholic drinks may properly be used, is an extremely difficult question. There is one thing which seems certain, — that spirits are more hurtful than wine and beer; and yet, even in countries where no spirits are used, many people are injured by too much wine, and the same was true in the times before alcohol and spirits were discovered,[1] and wine was the only drink of the kind known.

Another certain thing is that spirituous drinks cause great injury to the morals, and much crime. Men of great experience, judges, and keepers of prisons, say that one-half, or more, of the crimes they have to punish are caused by drinking. It is well known that many men are made poor by drinking. Whole nations of strong, healthy people, like our North American Indians, have been brought down by drunkenness from their former condition of free, brave, faithful men, to their present wretched state of vice and laziness, in which they are often a curse to all their neighbors.[2]

[1] Alcohol was discovered about 1000 A.D.

[2] This is the case more especially with those Indians that have long been settled near the whites, who supply them with rum. Indians living where they can get no rum are still in their former condition, hardy, brave, and active.

The following are among the known effects of alcohol on the organs and tissues: —

At the beginning, the heart beats quicker and with more force; also, the blood-vessels become larger, and the current somewhat slower in them. The skin is therefore reddened. This reddening, in habitual drinkers, may become permanent. These are bad effects; physicians can employ alcohol, however, for good purposes, in cases where there is danger to life from great weakness of the heart.

The rush of blood to the skin, caused by spirit, makes a person feel warm. This feeling is deceitful; the spirit brings no real warmth. It is in the highest degree dangerous to use spirits when men are exposed to cold and in danger of freezing. Arctic expeditions are now conducted on total-abstinence principles. The truth is, that alcohol cools the blood, and this can be proved in fevers by measuring the temperature with the thermometer. The proper use of spirits is to bring back strength to a chilled and exhausted person, for a few minutes, so that he may be able to rouse himself up and walk to a house, where he can get real warmth from a real fire.

The coats of the blood-vessels are apt to become slowly injured and weakened by the effects of alcoholic drinks. When this is the case, the arteries sometimes burst, which may cause death.

The stomach is often affected; sometimes the appetite is improved, as physicians know; at other times it is injured, as is often the case with old soakers who seem to live on drink instead of food. This latter state is a very dangerous one, and is likely to cause injury to the arteries, kidneys, heart, or liver; because alcohol does not really feed these organs as food does, but gives them an unwholesome support.

A certain disease of the liver, which is slow but fatal, has long been considered as due to spirit-drinking; it is called the "gin-drinker's liver"; another name is the "hob-nail liver," from the peculiar appearance of the organ, as if studded with heavy nail-heads.

The kidneys are often affected with a slow and fatal disorder called Bright's Disease, which has many causes, one of which is excess in alcoholic drink.

Gout makes the joints swell up, and gives horrible pain. It is made worse by some sorts of alcoholic drink; and these drinks, with other excesses in eating and drinking, are chief causes of gout.

All that may be said of the injury caused by alcohol applies with great force to young persons. The system is doubly injured by excesses in youth. A boy's frame is not able to stand such rough work as a man's, neither is his system as capable of enduring the effects of alcoholic drink as a man's may be. Persons who could stand the effects of tobacco and alcohol in adult life may be permanently injured by their use in boyhood. This is one reason — that youth has less power to resist poisons or bad influences of any sort than adult life has. The other reason is, that the forces of a youth's system are all needed to help in growing; and alcohol may, and often does, check the growth of young animals. The younger a person is, the more he is harmed; and for little children, it is as truly a poison, and a waster of life, as opium is.

Mention has been made of the use of alcoholic drinks in medicine. It is not proper to discuss this matter in a book like the present. It must be left to physicians to decide, in each case, whether they are required. It seems, however, to be a fact that it is less used for these purposes than was the case ten or twenty years ago.

TEA, COFFEE, CHOCOLATE.

There are very few nations in the world that do not use one or more of these drinks. The Chinese have used tea for thousands of years, and they seem at present to be a strong and hardy race, perhaps the most industrious on the globe. Chocolate is the favorite drink of the people of the hot parts of America. Coffee is very much used by the Mohammedan nations, and among all civilized races.

These drinks do not affect people in just the same way. They have different *flavors;* and these flavors, or odors, are due to the presence of certain volatile oils. To form a clear idea of what a volatile oil is, the reader may lightly scrape the rind of an orange with a knife, so as to break the small yellow globules, or cells, and notice that there is an oily feeling to the fluid which comes from the cells. There is also a strong odor to this orange oil: all volatile oils have strong odors. When hot water is poured on coffee, tea, or cocoa, a part of the oils is extracted by the water, and gives the flavor. As these oils differ from one another, the drinks have slightly different effects, though the greater effect is that due to the caffein. In addition to the volatile oils, these articles contain a substance which in large quantities is properly a poison, but in the small amounts found in the beverages is generally harmless. This substance is called thein, caffein, and cocoin: it is the same under each name.

One effect of tea and coffee seems to be, that if a person takes a good deal he can apparently do with less food. In this respect they are like alcoholic drinks. And they do harm when they take the place of food. Many persons have the very bad habit of making a meal of a cup of tea or coffee, either because they have not time to eat, or because they have not money to pay for food, or because they have no appetite. The drink makes them feel stronger for the time, and they do not feel the need of food; but that is only a way to cheat nature. Nature, however, will not be cheated, and when food is not taken, the system will suffer.

The effects of drinking too much tea are various. Many suffer from headache; many from constipation; many from nervousness or bad temper. Dyspepsia is frequent. Palpitation of the heart is not uncommon, and is a very distressing feeling. Coffee is, in general, similar in its action. Cocoa and chocolate affect some persons in the same way; but there is so much nourishment (of a rich, fatty sort, besides albuminoid matters) in these latter drinks that they are usually wholesome.

There is a good side to the question, however. Coffee has been found, in armies and on ships, to have a great power of keeping up the strength when men are tired and cold, as sailors and soldiers often have to be. It is altogether superior to alcoholic drinks, in such cases. The Russians, who know from experience the effects of a cold climate, drink a great deal of tea. A friend of the writer's has told him how, after travelling all day in dog-teams across the snow, he has drunk a dozen cups of hot tea at night, and has "turned in" and slept like a top till morning. Tea and coffee do not make people drunk and crazy; they do not rouse up low and immoral thoughts; they do not make people break the laws, as alcoholic drinks sometimes do.

Tea and coffee are generally harmless — or they may be beneficial — to persons who live a hardy out-door life with much muscular exercise. They are frequently harmful to those who live mostly in-doors, taking little exercise.

It would be much better for persons under adult age to be without these drinks. There are exceptions, but very few.

TOBACCO.

Tobacco contains an extremely poisonous volatile substance called nicotine, of which "mild" tobacco contains less than stronger sorts. It is very dangerous to swallow tobacco. Chewers usually spit out the juice; it would make them sick to swallow it. Some effect is produced by the small amount which enters the system by soaking through the mucous membrane of the mouth.

The smoker usually tries to get rid of a part of the nicotine. By the Orientals, this is accomplished by passing the smoke through water, which takes out a great deal of nicotine, and gives a mild effect. Our smokers throw away the cigar-stubs, in which the substance accumulates. The North American Indians did exactly the opposite in their grand councils; they

economized the effects by swallowing a little smoke, and passing the pipe to the next man.

It is often said by smokers that cigarettes are more injurious than other forms of using tobacco.

Every one knows the sickness which the first use of tobacco causes. After a while the system gets used to it, and, indeed, cannot do without it: it is terribly uncomfortable to have to give up tobacco, if one has the habit.

Does tobacco do harm? To many persons it seems to do no harm. That which at first made a person feel as if he were dying, soon gives no discomfort, and, in fact, makes one feel pleasantly. Smokers say that it makes them feel comfortable when they are tired with hard work. The persons who are most injured are those who do no hard bodily work. Many such are undoubtedly injured. Some of the chief effects are, in such cases, a kind of weakness, a nervousness, and trouble with the stomach. It is not uncommon to find persons suffering with palpitation of the heart, caused by tobacco. Others have weak sight from the same cause. The general effect seems to be, to weaken the nervous system.

For young persons, not grown up, the same thing may be said as in the case of alcoholic drinks, tea, and coffee. They will probably grow up stronger in muscle, more able to run, jump, box, and row, if they grow up without these things. Of tobacco, in particular, it is noticed that boys who use it are apt to become lazy; they like better to huddle together in some warm corner than to rush about after the football. It is apt also to make them a little stupid while they are using it.

APPENDIX I.

THE following extracts are taken from the writings of medical men of the highest reputation for scientific knowledge and clear judgment. They may be regarded as unprejudiced statements of fact, made upon the best authority, and with the best light that our present scientific knowledge imparts.

ALCOHOLIC BEVERAGES.

From "Treatise on Food and Dietetics," by F. W. Pavy, Fellow of the Royal College of Physicians, and Lecturer on Physiology at Guy's Hospital, London. 2d edition, 1881 (Wood & Co.), p. 237.

Alcoholic beverages, taken in moderate quantity, increase the activity of the circulation. The heart beats more rapidly. The pulse becomes not only more frequent, but at the same time fuller. The arteries dilating allow the blood to flow more freely to the capillaries, thus leading to turgescence of the small cutaneous vessels, and accounting for the flushing of the face that is noticeable. . . . The warm blood from the interior, circulating more freely over the surface, imparts a temporary glow to external parts; but the outside is warmed at the expense of the inside. The amount of the urinary secretion is increased, the appetite augmented, digestion promoted, the nervous system stimulated, and the mental faculties exhilarated. In moderate quantities, in short, observation shows that the alcoholic beverages act as a general stimulant.

Dr. Parkes has submitted to direct investigation the question whether the effect of alcohol is to increase or diminish the facility with which work is performed. In one of his series of observations a soldier passed a period of three days performing a certain amount of work without the use of brandy; and, after three days of rest, another period of three days of work with twelve ounces of brandy *per diem*, administered in four-ounce doses, at 10 A.M., 2 P.M., and 6 P.M. The man was requested to observe as closely as he could whether he did the work better with or without the brandy. He commenced the

brandy period, it is stated, with the belief that the brandy would enable him to perform the work more easily, but ended with the opposite conviction. The work performed was chiefly done in the two hours immediately succeeding each dose of brandy. The two hours' work after the first four fluid ounces appeared to be accomplished equally well with and without the brandy. The man, it is said, could tell no difference except, to use his own words, "the brandy seemed to give him a kind of spirit which made him think he could do a great deal of work, but when he came to do it he found he was less capable than he thought." After the second four ounces of brandy, at 2 P.M., he felt hot and thirsty, but on the first two days thought he worked as well as on the water days. On the third day, however, the report says that he had palpitation of the heart, and was surprised to find that he was obliged to stop from time to time because of his breathing not being so good. The third four fluid ounces of brandy, taken at 6 P.M., produced on all three days very marked narcotic effects. The account given is that "immediately after taking it he became heavy, felt the greatest indisposition to exert himself, and could hardly refrain from throwing down his spade and giving up his work. He worked with no vigor, and on the second evening thought his muscular power was decidedly lessened. On the third evening it was raining; he could not dig, but took walking and running exercise under cover. On attempting to run, he found, to his great surprise, as he is a particularly fast and good runner, that he could not do so. He had palpitation, and got out of breath, and was obliged to stop."

The experience of this man harmonizes with the advice that is given by guides and others who are in the habit of undertaking the ascent of mountains. Spirits, they say, take away the strength from the legs, and should, therefore, be avoided during a fatiguing expedition.

Some further evidence has also recently been published by Dr. Parkes, upon the subject under consideration, drawn from the experience of the Ashanti campaign of 1874. In an introduction to the report he says: "The first effect of alcohol, when given during a march in a moderate dose (for example, what is equal to one fluid ounce of absolute alcohol, the amount contained in about two and a half fluid ounces of ordinary spirits), is reviving, but this effect is transient. The reviving effect goes off after, at the utmost, two and a half miles of additional march, and sometimes much before this; then the previous languor and sense of exhaustion not only return, but are sometimes more intense; and if alcohol is again resorted to, its effects now

are less satisfactory. Its reviving power is usually not so marked, and its peculiar anæsthetic and narcotizing influence can often be distinctly traced. The men feel heavy, dull, disinclined to march, and are less willing and cheerful."

Whilst the general testimony resulted in condemnation of the employment of spirits as a restorative *during* the fatigue of marching, the evidence on the other hand went strongly to show that, issued after the day's fatigue was over, the spirit-ration exerted a beneficial, reviving effect, and afterward induced an increased feeling of warmth, accompanied by the promotion of sleep. Upon these points Corporal Hindley, who had been always a temperate man and never in the habit previously of taking spirits, expressed himself as follows: "Had two rations of rum (a ration equal to two and a half fluid ounces) on the way to the Prah, taken in the evening just before going to bed. Thought it useful; when there was no issue, felt chilly and cold at night; felt warmer when he had taken the rum, and slept better; had no doubt about sleeping warmer and feeling better. On the next day felt no ill effects from the rum."

The writings of Dr. Anstie and Dr. Parkes agree in assigning about one fluid ounce of absolute alcohol, which is equivalent to two and a half fluid ounces of ordinary spirits, as the limit of moderation for a dose, or the quantity that can be disposed of in the organism of an adult male without producing any perceptible injurious effect upon the bodily functions. Up to this quantity its action is that of a stimulant; but beyond, it begins to exert a narcotizing influence, and when taken to excess, a more or less profound state of narcotism, as common observation but too abundantly testifies, may be induced. The effects now witnessed upon the general system are no longer those of a stimulant, but exactly the reverse, and hence to describe its action in large doses, it may be spoken of as a depressant and narcotic.

It has been stated[1] that, when consumed in moderate quantity, the alcoholic beverages appear to encourage the appetite and promote digestion. Taken in excessive quantity, however, nothing with greater certainty destroys the appetite and impairs digestion.

[The author of the present work would add that the Ashanti expedition offered peculiar advantages for ascertaining the truth in regard to the question before us. The climate of the

[1] *I.e.*, by the author here quoted.

country is so unwholesome for Europeans that no English force could have lived in it, except during the few weeks of the comparatively healthy season. To insure the health of the army, the government consulted the best medical authority upon all points, and followed their advice with remarkably good success. The use of spirits by the men was entirely under control.]

THE ABUSE OF ALCOHOL AND TOBACCO IN YOUTH.

Thomas More Madden, M.D., F.R.C.S., Dublin, President of the Obstetric Section of the British Medical Association. In "Cyclopedia of the Diseases of Children," Lippincott, 1889, Vol. I., p. 411.

The painful exhibitions of juvenile drunkenness daily witnessed, especially among the neglected street Arabs, who during or even before the first stage of puberty are forced into the thoroughfares of our great cities, there to eke out a living as best they may, the pathological consequences of whose acquired or inherited alcoholism are brought under clinical observation in the form of gastric and hepatic disorders, and especially cirrhosis of the liver, as well as in the protean forms of cerebro-spinal disease, and the various neuroses which are so frequently noticed in hospitals for children.

In the British Medical Journal and elsewhere I have reported several instances of juvenile alcoholism that came under my care in the Children's Hospital, and latterly some deaths from this cause have occurred among mere lads. In the majority of cases of juvenile alcoholism, this tendency appears inherited, and is most marked in those whose mothers were inebriates, — intemperance in women also bearing in other ways on the diseases treated in hospitals for children, where its effects are strikingly evinced by the moral and physical deterioration of the offspring of the drunken, and by their special predisposition to strumous, tubercular, and other constitutional taints.

The evil thus resulting from the prevailing intemperance of the young as well as the old should induce us to warn those whom our counsel may influence against that custom of giving alcoholic stimulants to children, which is so general in its practice among all classes and so calamitous in its results. Even in those exceptional cases in which such stimulants may be necessary, we should never sanction their administration save under the guise and in the definite doses of

other remedial agents; and my experience in hospital and private practice, at home and abroad, has amply confirmed the view expressed in a work of mine published many years since, that *it is physiologically wrong, as well as morally unjustifiable, ever to allow a healthy youth to taste alcohol in any form.*[1]

With regard to the effects of the abuse of tobacco during early puberty, of which we see so many instances, especially among the neglected children of the poor, I may refer to an observation I long before made on the stunted and prematurely aged appearance of children in Portugal, where smoking is indulged in from the earliest possible age. There, in the streets of Lisbon, I have often seen with astonishment boys obviously much under the age of puberty gravely sucking a strong cigar with apparently the same gusto which our less precocious progeny derive from the forbidden delights of the sugar-stick. There can be no doubt that the influence of the nicotine thus absorbed must be most injurious at this age; and this is evident in the physical aspect of the youths referred to.

MEDICAL OPINION OF ALCOHOL.

William H. Draper, Annual Discourse delivered before the New York Academy of Medicine, Nov. 8, 1886. "New York Medical Record," Nov. 27, 1886.

I believe I am speaking within bounds when I say that the majority of thoughtful physicians who have studied carefully the effects of what is regarded as the moderate, as well as the immoderate, use of alcoholic beverages, are persuaded that as foods, excepting possibly in the febrile states, their value has been largely over-estimated, and that in the normal condition of the body they are not only quite unnecessary to the maintenance of healthy nutrition, but are always more or less baneful in their effects. That they add, as Matthew Arnold has said, to the agreeableness of life, that their use is universal, that through their stimulating influence upon the nervous centres they have been potent factors in the progress of civilization, and that they are of inestimable value as stimulants and anæsthetics, are considerations entirely apart from the facts concerning them which are especially interesting; namely, their effects on nutrition; that these are harmful and deteriorating to such a degree as to constitute the most powerful cause of

[1] Italics by author of this book.

physical degeneration at the present day, there can, I think, be no question. The drift of professional opinion in this country and in Europe is surely tending toward the restriction of their use as articles of diet, and simply for the reason that they are the determining cause of many functional derangements and structural degenerations.

EXPOSURE TO YELLOW FEVER.

When persons are exposed to yellow fever, "Spirituous liquors, if used at all, should be taken in great moderation. Nothing is more likely to develop an attack than alcoholic excesses, and the habitual drunkard is almost doomed to death if he falls sick with this disease." —From Prize Essay by George M. Sternberg, M.D., U. S. Army; published by the American Public Health Association in 1886.

CIGARETTES.

The following is extracted from a report addressed by Willis G. Tucker, Analyst to the New York State Board of Health, under date of Feb. 28, 1888:—

"No traces of opium or arsenic, nor evidence of the presence of any other poisonous substance foreign to the tobacco, was discovered in any of the [brands of cigarettes examined].

"Should stress be laid upon the fact that several deaths have been attributed to the use or abuse of cigarettes within the last few years, it should be remembered that in none of these cases, so far as I am aware, has it been claimed that the harmful effect was produced by any foreign substance. On the contrary, it has been attributed to the influence of the tobacco upon the nervous system and heart, there being little doubt that the excessive use of tobacco may work irreparable injury in some cases. And herein lies the chief danger from the use of cigarettes. Being small, easily carried about, inexpensive, and everywhere obtainable of good quality, which is by no means the case with cigars, they are doubtless more likely to be used to excess than is tobacco in any other form; and since cigarette-smokers usually inhale the smoke, the products of the combustion of the tobacco more readily and rapidly gain access to the system by direct absorption into the circulation than when used in any other way. Cigarettes are objectionable likewise because more likely to be smoked by children; and whatever may be said concerning the effect of tobacco on adults,

all authorities agree in the statement that it exercises a baneful effect upon the young." — Ninth Annual Report of New York State Board of Health, pp. 516–518.

ALCOHOL AS AN ARTICLE OF DIET.

"A Manual of Practical Hygiene," by E. A. Parkes and F. S. B. de Chaumont. Sixth edition, 1883 (Blakiston, Son & Co.).

The subject is treated at considerable length in this work. The following extracts are quoted from the conclusions reached: —

"The obvious useful physiological actions of alcohol are an improvement in appetite, produced by small quantities, and an increased activity of the circulation, which, within certain limits, may be beneficial. It is difficult to perceive proof at present of any other useful action, since it is uncertain whether, during its partial destruction in the system, it gives rise to energy." p. 296.

"It may be considered, then, that the limit of the useful effect is produced by some quantity between 1 and 1½ fluid ounces [of alcohol] in twenty-four hours. . . . For children there is an almost universal consent that alcohol is injurious, and the very small quantity which produces intoxication in them indicates that they absorb it rapidly and tolerate it badly." p. 286.

"There is no difficulty in proving, statistically, the vast loss of health and life caused by intemperance; and the remarkable facts of the Provident Institution show the great advantage total abstainers have over those who, though not intemperate, use alcohol more freely. But it is almost impossible, at present, to compare the health of teetotallers with those who use alcohol in the moderate scale given above [see previous paragraph]. In both classes are found men in the highest health, and with the greatest vigor of mind and body; in both are to be found men of the most advanced age. If the question is looked at simply as a scientific one, it is hardly possible at present to give an answer." p. 297.

"The facts now stated make it difficult to avoid the conclusion that the dietetic value of alcohol has been much over-rated. It does not appear possible at present to condemn alcohol altogether as an article of diet, or to prove that it is invariably hurtful, as some have attempted to do. It produces effects which are often useful in disease and sometimes desirable in health, but in health it is certainly not a necessity, and many persons are much better without it. As now used by man-

kind (at least in our own and many other countries) it is infinitely more powerful for evil than for good; and though it can hardly be imagined that its dietetic use will cease in our time, yet a clearer view of its effects must surely lead to a lessening of the excessive use which now prevails." p. 305.

[It may be added that the work here quoted from is probably at present the highest authority upon general hygiene in our language. It is particularly emphatic in condemning the use of alcoholic drink in military or naval life.]

APPENDIX II.

DISSECTION OF ANIMALS.

If the teacher is willing to take a little additional trouble, he will find himself well repaid by a view of the internal organs of a small animal, as the dog, cat, or rabbit. It is best, of course, to go through with the dissection privately before attempting to dissect for a class. The work does not require muscular strength, for the parts yield readily to a sharp knife, and even the ribs are easily cut through with strong scissors or nippers.

The apparatus required for the dissection is a good-sized tray, a towel, basin of water, fine string, small blow-pipe, light, sharp knife, light forceps, common blunt-pointed scissors.

Any small animal will serve the purpose. The cat, however, is often the most convenient. A painless death is secured by chloroform. Professor Wilder, in his very thorough work "Anatomical Technology of the Cat," recommends the use of a tight box with a sliding door; the bag containing the cat is opened in such a way as to allow the animal to enter the door, — which she proceeds to do without fuss; the door is then shut; a sponge containing two teaspoonfuls of chloroform is quickly inserted, and in a few minutes life peacefully departs.

The animal being laid on his back, and the paws stretched and tied to any convenient objects, the knife is passed under the skin at the chin, and the skin is divided by one cut straight down to the lower part of the belly, without injuring the muscles. The skin is then pulled off with the fingers to the right and left, with the aid of light strokes of the knife. The cartilages of the ribs are readily seen in front. Cut them near where they join the ribs. Raise the cartilages as one piece, exposing the heart and lungs. Avoid injuring the lungs; but, to provide against that accident, you may inflate the lungs at this stage by passing the tube into the trachea and blowing; they will shrink to a small compass afterwards, and leave you free to disengage the heart. This operation should be done carefully, tying the aorta and the two venæ cavæ twice, and cutting between the ligatures to prevent bleeding. The organ closely resembles that of man in form.

After studying its outward appearance with the aid of the plates, you may remove the ligatures and wash out the blood with a fine syringe, introduced at each auricle; after which, if you choose, fill the cavities with alcohol of ninety-five per cent strength, tie the orifices, and suspend the heart in alcohol for two days by a pin passed through the tip of the organ. Windows can then be cut with a knife in the hardened tissue so as to show the interior and the valves beautifully.

The lungs can be removed and put in water to observe their lightness. The diaphragm is now in a convenient position for study. Afterwards the abdominal cavity should be opened by a cut through the muscles in front, when the stomach is seen just below the diaphragm, with the intestines, and at one side the liver. Behind the mass of intestines lie the two kidneys, and lower down the bladder (which should have been emptied previously, to prevent disagreeable accidents). The stomach can be opened without causing serious offence to the senses, most conveniently by a cut along the large curvature. Continuing through the pylorus into the small intestine, we find the character and odor of the contents at once changed.

The gall-bladder, the internal structure of the liver, kidneys, spleen, and pancreas, can be examined with ease. The circulation in the great network which holds the intestines in place is easily seen, converging towards a point near the liver.

APPENDIX III.

TREATMENT OF THE DROWNED.[1]

Two Things to be done: Restore Breathing; Restore Animal Heat.

Rule 1. — **Remove all obstructions to breathing.** Instantly loosen or cut apart all neck and waist bands; turn the patient on his face, with the head down hill; stand astride the hips with your face towards his head, and, locking your fingers together under his belly,

Fig. 1.

raise the body as high as you can without lifting the forehead off the ground (Fig. 1), and give the body a smart jerk to remove mucus from the throat and water from the windpipe; hold the body suspended long enough to slowly count one, two, three, four, five, repeating the jerk more gently two or three times.

Rule 2. — Place the patient on the ground face downward, and, maintaining all the while your position astride the body, grasp the points of the shoulders by the clothing, or, if the body is naked, thrust your fingers into the armpits, clasping your thumbs over the points of the shoulders, and **raise the chest as high as you can** (Fig. 2) with-

[1] As given by the Michigan State Board of Health.

out lifting the head quite off the ground, and hold it long enough to *slowly* count ONE, TWO, THREE. Replace him on the ground, with his forehead on his flexed arm, the neck straightened out, and the mouth

FIG. 2.

and nose free. Place your elbows against your knees, and your hands upon the sides of his chest (Fig. 3) **over the lower ribs, and**

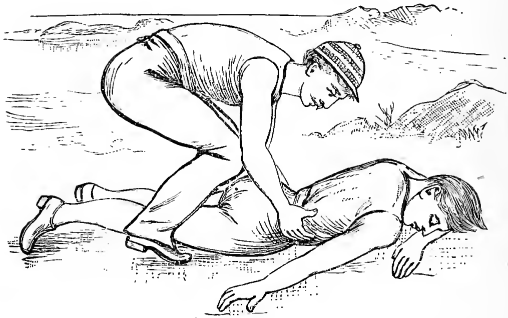


FIG. 3.

press downward and inward with increasing force long enough to slowly count ONE, TWO. Then suddenly let go, grasp the shoulders as before, and raise the chest (Fig. 2); then press upon the ribs,

etc. (Fig. 3). These alternate movements should be repeated 10 or 15 times a minute for an hour at least, unless breathing is restored sooner. Use the same regularity as in natural breathing.

Rule 3. — After breathing has commenced, RESTORE THE ANIMAL HEAT. Wrap him in warm blankets, apply bottles of hot water, hot bricks, or anything to restore heat. *Warm the head nearly as fast as the body, lest convulsions come on.* Rubbing the body with warm cloths or the hand, and slapping the fleshy parts, may assist to restore warmth, and the breathing also. If the patient can SURELY swallow, give hot coffee, tea, milk, or a little hot sling. Give spirits sparingly, lest they produce depression. Place the patient in a warm bed, and give him plenty of fresh air; keep him quiet.

BEWARE!

Avoid Delay. A MOMENT may turn the scale for life or death. Dry ground, shelter, warmth, stimulants, etc., at this moment are nothing — ARTIFICIAL BREATHING IS EVERYTHING, — is the ONE REMEDY, — all others are secondary.

Do not stop to remove wet clothing. Precious time is wasted, and the patient may be fatally chilled by exposure of the naked body, even in summer. Give all your attention and effort to restore breathing by forcing air into, and out of, the lungs. If the breathing has just ceased, a smart slap on the face or a vigorous twist of the hair will sometimes start it again, and may be tried incidentally.

Before natural breathing is fully restored, do not let the patient lie on his back unless some person holds the tongue forward. The tongue by falling back may close the windpipe and cause fatal choking.

Prevent friends from crowding around the patient and excluding fresh air; also from trying to give stimulants before the patient can swallow. The first causes suffocation; the second, fatal choking.

Do NOT GIVE UP TOO SOON: You are working for life. Any time within two hours you may be on the very threshold of success without there being any sign of it.

In suffocation by smoke or any poisonous gas, as also by hanging, proceed the same as for drowning, omitting effort to expel water, etc., from windpipe.

In suspended breathing from effects of chloroform, hydrate of chloral, etc., proceed by Rule 2, taking especial pains to **keep the head very low**, and preventing closure of the windpipe by the tongue falling back.

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